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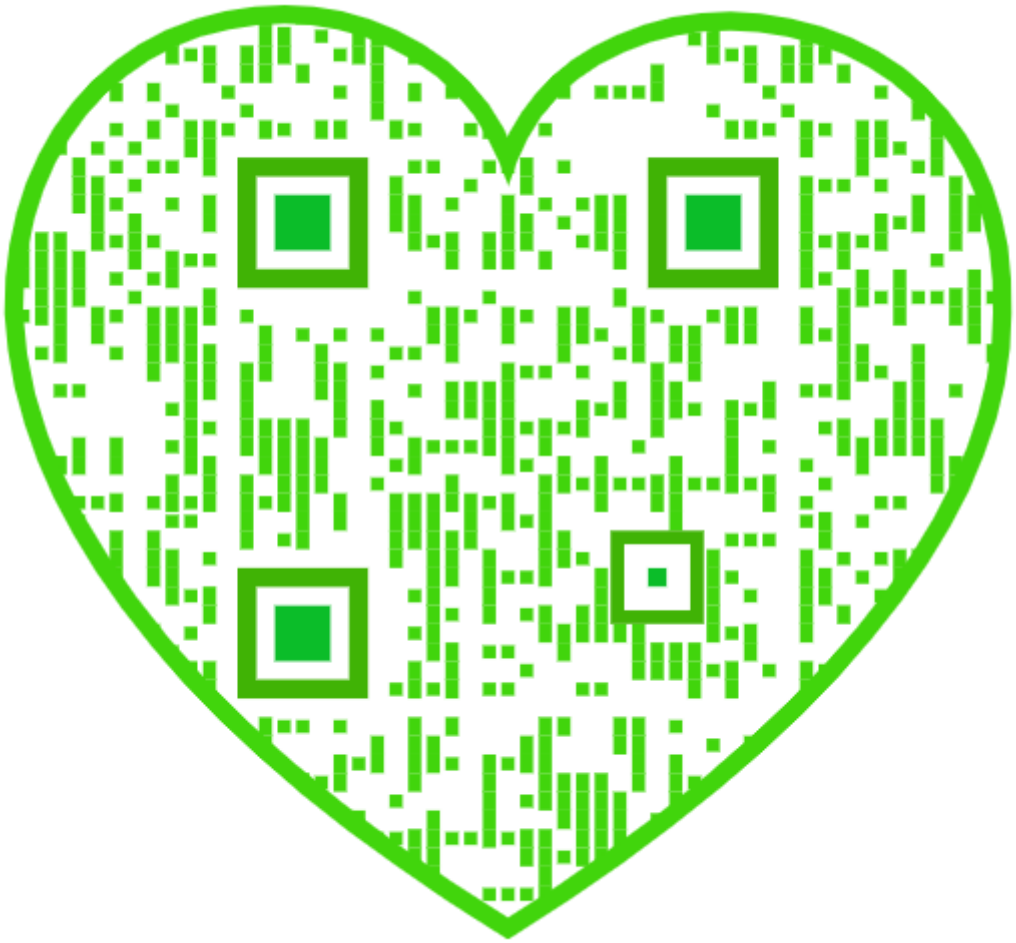

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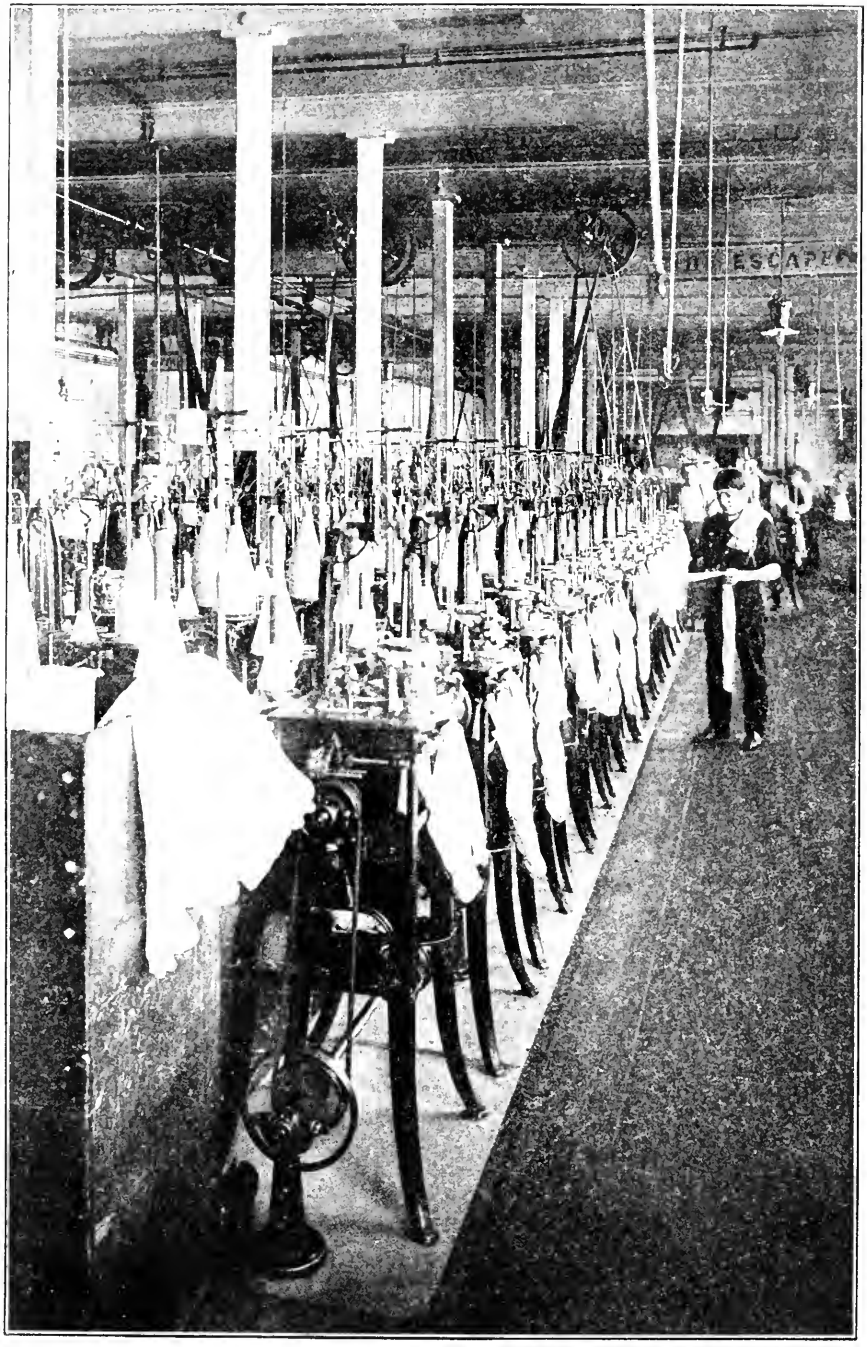

HOSE KNITTING ROOM, AUTOMATIC SEAMLESS MACHINES

Lawrence Mfg. Co.

Knitting

A Manual of

PRACTICAL INSTRUCTION IN THE MECHANICAL DETAILS OF ALL TYPES OF KNITTING MACHINERY, THEIR OPERATION, ADJUSTMENT, AND CARE

By M. A. METCALF
Managing Editor, "The Textile American"

ILLUSTRATED

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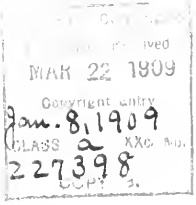

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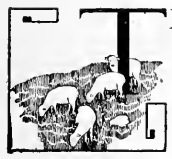
Foreword



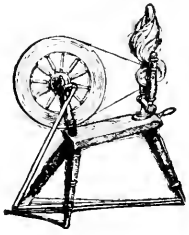
HE Textile Industry has shared to such an extent the modern tendency toward specialization, and has been marked by the development of such a multiplicity of types of machinery and special mechanical and chemical processes, that the various branches of this great industry to-day constitute in reality distinct though closely related arts. The present volume is intended to furnish a comprehensive treatment of the important subject of Knitting, and to serve as a practical working guide to all details of this rapidly developing branch of the modern textile industry.

¶ Special stress is laid on the *practical* as distinguished from the merely theoretical or descriptive form of treatment, the work being based on a careful study of machinery, conditions, and needs as developed in the best American mills.

¶ This volume will be found especially adapted for purposes of self-instruction and home study. Covering fully the mechanical details of all types of knitting machinery and their operation, adjustment, and care, it is fitted not only to meet the requirements of a manual of instruction for the beginner, but also to serve as a reference work replete with information and suggestions of the utmost practical value to the most advanced and experienced worker.

¶ The method adopted in the preparation of this volume is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests — that of practical use—which has demonstrated it to be the best method yet devised for the education of the busy workingman.

¶ For purposes of ready reference, and timely information when needed, it is believed that this volume will be found to meet every requirement.



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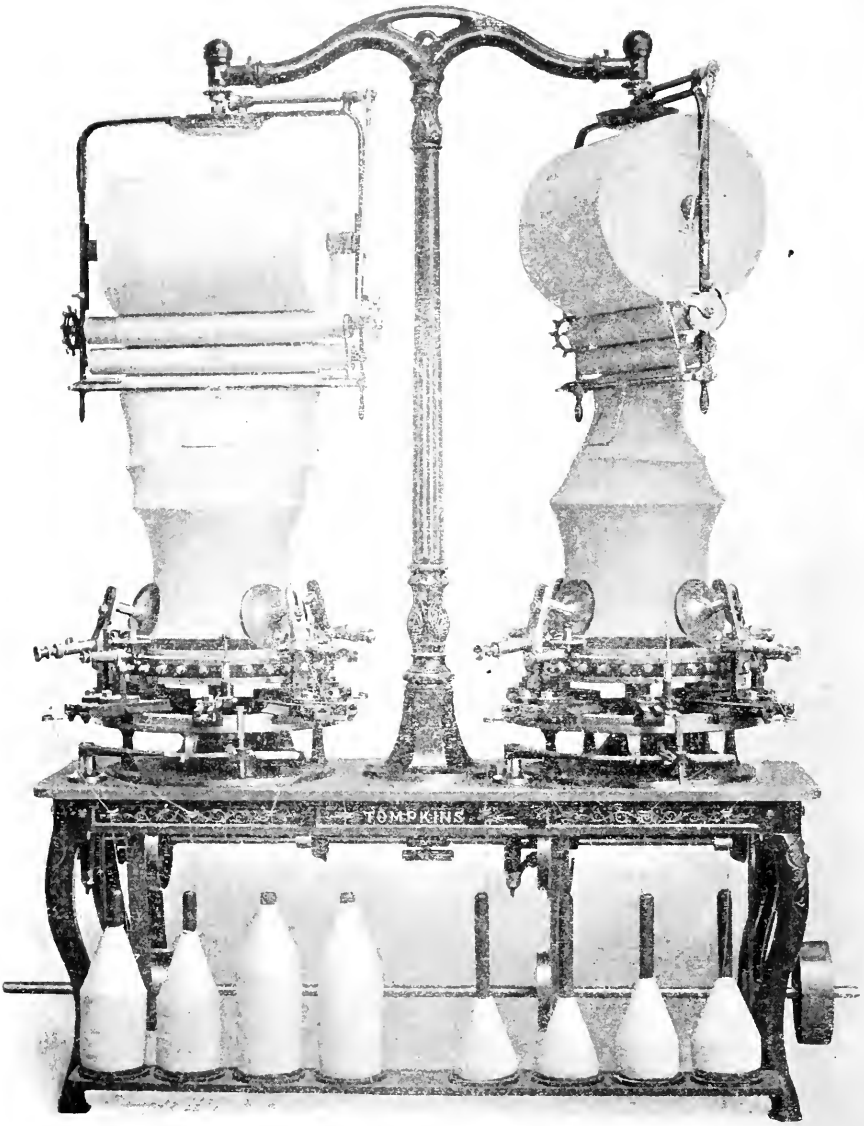


CIRCULAR SPRING-BEARD NEEDLE LOOP WHEEL MACHINE FOR MAKING PLAIN WEBBING

Tompkins Bros. Co.

KNITTING.

PART I.

CYLINDER SPRING NEEDLE KNITTING.

There are several kinds of knitted fabrics made in knitting mills, each kind requiring a radically different machine to produce it. What are commonly called *Flat Goods* are knit on Circular *Spring* Needle machines. *Ribbed Goods* are knit on Circular *Latch* Needle Machines. Shirt borders or rib tails, shirt cuffs or ribs, and drawer bottoms or ribs with selvedge edge, welt and slack course, are made on Straight Spring Needle Rib Machines, though some ribs for sleeves and drawer legs are made on small circular latch needle machines. Full Fashioned Underwear is made on Straight Spring Needle Machines provided with means for narrowing or shaping the garment to fit the body and limbs. The latest type is for knitting Ribbed Goods on a Circular Spring Needle Rib Machine. Hose is knit on Circular Latch Needle Machines generally, but of a different type than the machines for knitting Ribbed Underwear. Full Fashioned Hose is knit on Straight Spring Needle Machines with widening and narrowing devices for shaping the stocking, and Straight Latch Needle Machines.

It is evident from the above that knitting may be classified in a general way under three headings, viz : —

Flat Goods.

Ribbed Goods.

Hose or Stockings.

The first two classes include men's shirts and drawers, and ladies' vests and pants ; the third class including full length and half hose, full fashioned, shaped or cut, and seamless. A knitter should be well skilled in the art of knitting in all three classes to be competent to fill the best positions and obtain master's pay.

THE CONE WINDER.

The soft yarns, wool and mixtures and the backing yarns for cotton faced ribbed goods, are usually prepared, picked, carded

and spun in the mill where they are knit up. Hard or cotton yarns are in most cases purchased in the market,— such yarns are used for ribbed goods, balbriggans, etc.,— but both kinds come to the knitter on jack bobbins or cops, and to facilitate the knitting are wound off on a much larger bobbin called a winder bobbin. The greatest care should be taken to have the yarn in the best possible condition on these bobbins. One of the most important factors in the production of knit goods is the proper presentation of the yarn to the knitting machine.

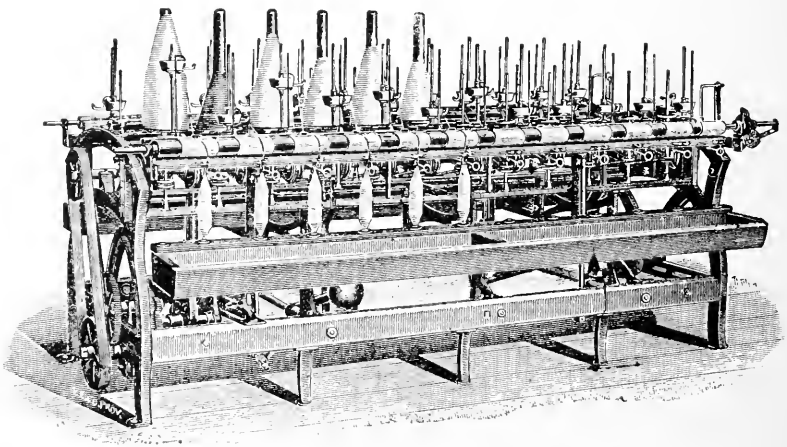


Fig. 1. Cone Winder.

Winding. When an end breaks down on a winder, the operator should not be allowed to flip the end on to the partly wound bobbin and let it go, because the result is almost sure to be a press-off when the yarn runs out on the knitting frame, especially when the knitting frame is not provided with automatic stops. The operator should be made to find the ends and tie them together in a small neat knot, and without forgetting to pull the ends through and break them off at the proper distance from the knot. If it is improperly or carelessly tied, leaving the ends in the knot, it leaves a loop and a larger knot, making a bunch in the yarn that will cause holes in the cloth and oftentimes break a number of needles — what the knitters call a "smash." If the knitter insists that the winders run the yarn through the scrapers on the winder, and tie

every broken end properly, he will avoid many a hole in the cloth, break less needles and get a larger production of better fabric. The winding is the last handling of the yarn before it goes into the knitting needles and the real operation where the keenest inspection can be made. All the defects as seeds, sticks, knots, lumps, slugs, etc., that are removed in this process will materially affect the quality of the fabric, the production, and the cost of repairs, the three prime objects that must be kept in view to excel in the art of knitting.

Fig. 1 gives a comprehensive view of a Payne Cone Winder, winding from cop to knitting or winder bobbin; they are easily changed to wind from jack bobbin or skein. It is practically automatic, requiring but little attention from the operator except to replace the empty cops, tie the ends and remove the filled bobbins. As each spindle is independent and has its own stop motion, each bobbin is of course independent of the others and when filled may be stopped, taken off and another started in its place without stopping any of the other bobbins. This permits continuous winding.

The filling or building motion to each spindle adjusts itself to fine or coarse yarns without attention of the operator so that several different numbers of yarn can be wound on different bobbins at the same time if required. If the winder is kept in good order, the yarn will come off the bobbin when fed into the knitting machine with an almost constant tension instead of coming off two or three turns at a time in which case it is liable to catch and make bad places in the cloth, break the yarn, break needles and cause other annoyances. The winder bobbins should be handled with care after being filled on the winder to preserve their initial shape and the lay of the yarn, and thereby ensure a free delivery of the yarn when delivered to the needles.

When this machine is set up it should be leveled and belted to run the receiving shaft 160 to 180 revolutions per minute. Particular pains must be taken to see that an uneven floor or other causes do not throw the machine out of alignment; if it does then it must be shimmed up until level its entire length. When the cone winder is taking more power to run it than seems necessary, it will be found in most every case to be out of alignment and

immediate attention to putting it into line will usually remedy the difficulty. The machines vary in size from six to forty-eight spindles as required, and may be adjusted to wind a bobbin from four to six inches in diameter 17 inches high, leaving the top, cone-shaped, as observed in Fig. 2.

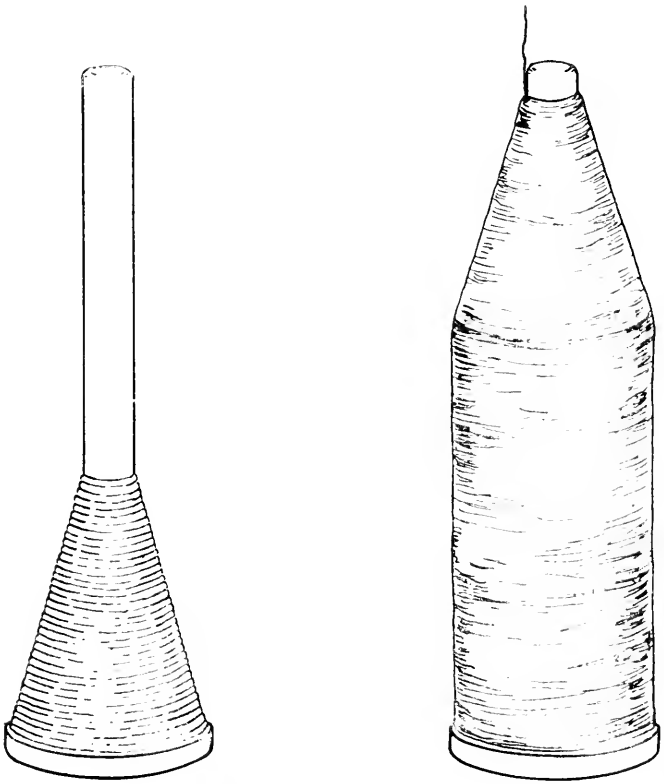


Fig. 2. Winder Bobbin, Empty and Filled.

The action of the cup attached to the filling or building motion controls the diameter of the bobbin, four to six inches as predetermined, or any size between. The building motion has a rise and fall corresponding to the height of the cone-shaped part of the empty bobbin and maintains that same rise and fall until the bobbin is filled. Tensions are so regulated that the yarn may be wound as tightly at the nose or small part of the bobbin as at the base or large part.

Spindle Drive. The top of the machine, between the rails that move up and down, is covered with light boarding; just beneath this covering is the receiving shaft extending the full length of the machine, on which are the band pulleys driving the spindles; each pulley has a double groove, as it drives a spindle on either side of the machine, transmitting with a round cotton banding, a separate band to each spindle, as in Fig. 3.

Building Motion. At one end of the shaft is the receiving pulley; at the other end is another pulley also outside of the frame, for transmitting power to the building motion inside the lower part of the machine as in Figs. 4 and 5. In a bearing fastened to

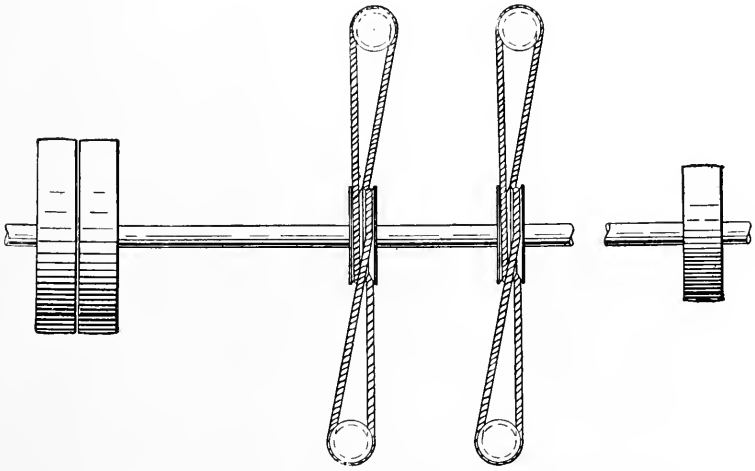


Fig. 3. Spindle Drive Showing Pulleys and Bands.

the end of the frame is a jackshaft on which, outside the end frame and close beside the belt pulley, is a pinion gear meshing into a wheel gear that drives, on its shaft inside the frame, an unusual arrangement of gears — double gears — so arranged that the teeth on one pair are just half the distance of one tooth ahead of the other pair. Such an arrangement serves to materially lessen the back-lash that must inevitably occur were but one pair of gears only employed. This system of gearing transmits motion to the heart cam shaft that gives the rise and fall to the building motion. The reversing at each end of the stroke is attended in similar

mechanisms with more or less back-lash which in this machine is controlled by this double gear arrangement.

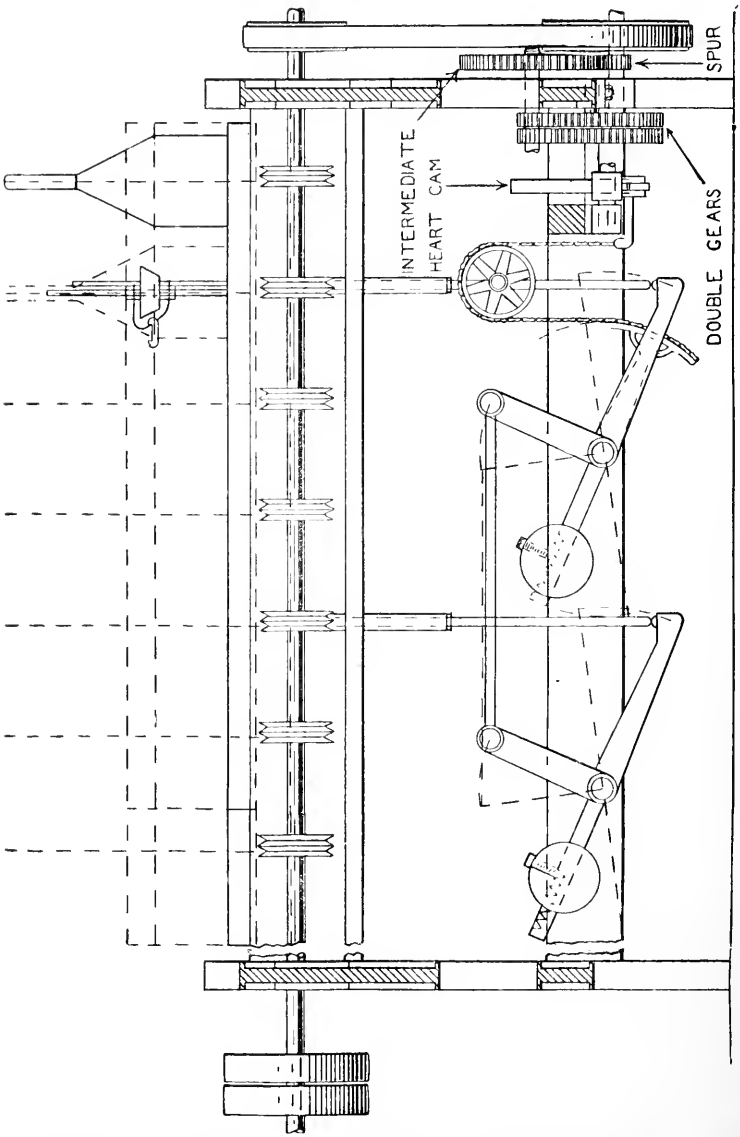


Fig. 4. Sectional View of Side Showing Building Motion.

The heart cam Fig. 6 has a long and short side, imparting to the building rail a slow rising movement, making a close wind on the bobbin and a quick falling movement which lays the yarn

across the close wind and binds it in a manner best adapted for use on a knitting frame. The building rail, see Fig. 4, is connected with the heart cam in the following manner: By action of the cam, a lever on a rockshaft parallel to the cam shaft, with a cam roll near the vibrating end is made to transmit its motion by means of a chain belt attached to the above lever and running over an idler wheel to connect it with another rockshaft lever at right angles with the cam shaft. On this rockshaft another

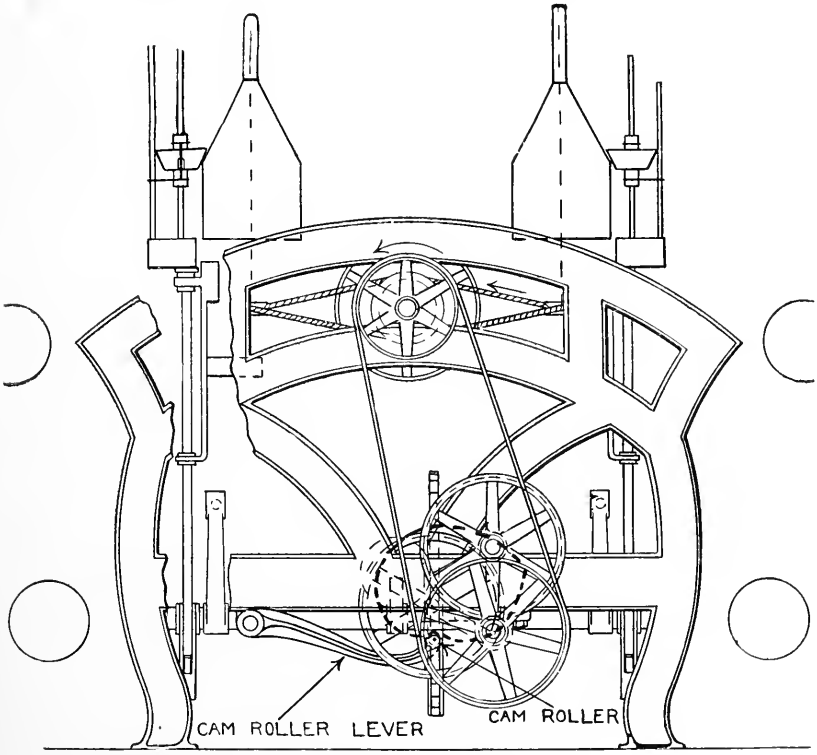


Fig. 5. End View of Cone Winder.

lever, connected by upright rods to the building rail, gives to it a rise and fall corresponding to the height of the cone-shaped portion of the winder bobbin. On a third lever of this rockshaft is a ball weight to equalize the motion, balance the weight of the cup rail or building rail, and thereby relieve the heart cam of excessive wear when lifting the rail. The upright rods to the building

rail are near each end of the rail: the rockshaft with lifting rod lever and ball counterweight is consequently duplicated at the opposite end of the machine, the rockshaft being connected with rod and levers. The upright rods are not connected to the levers, but, having a broad heel, ride easily on a small roller wheel in the ends of the levers. This arrangement permits a free sweep of the levers with a minimum of friction.

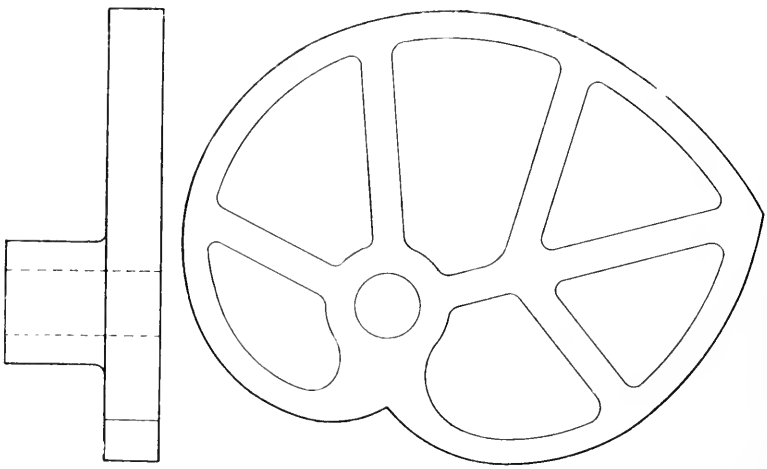
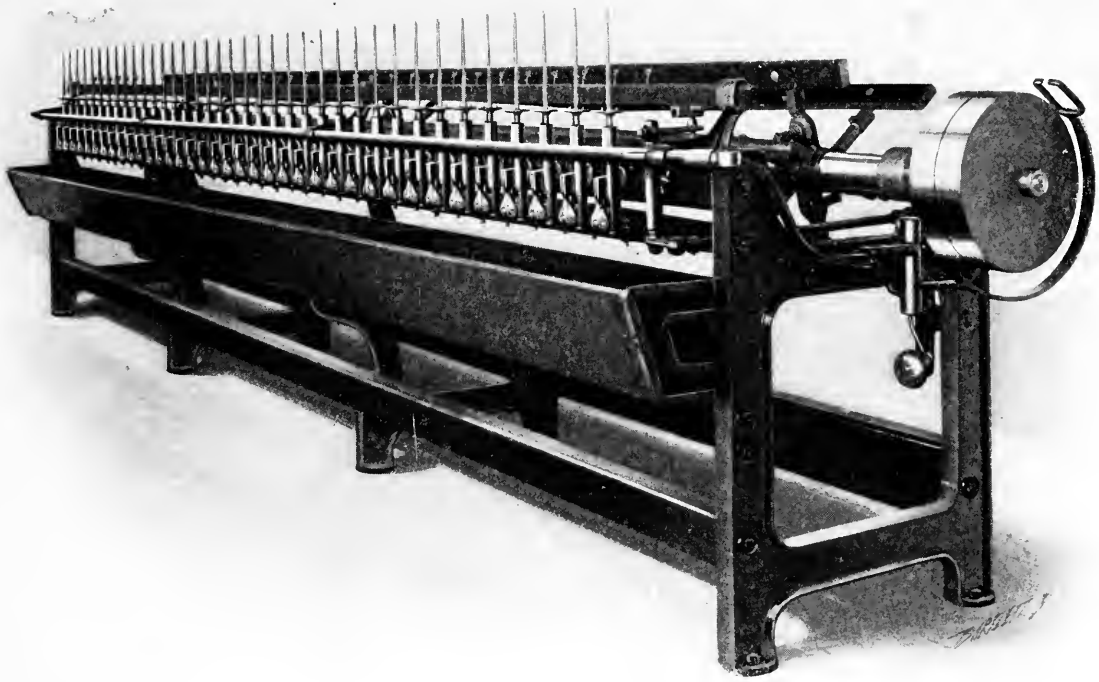


Fig. 6. Heart Cam.

The Spindles are properly stepped and run in oil with a cap closely fitted to the spindle and covering the step to keep out grit and lint. If the caps are kept in position the steps will last a long time. About eight inches above the step rail just beneath the board covering is the bolster rail with the spindle bearing. Just above the covering, fastened to the spindle with a taper bearing, is a flange on which the bobbin rides, held on by the spindle projecting up into the hole in the bobbin made for that purpose. On that part of the spindle between the step and the upper bearing is fastened the whorl for belting the spindle.

The jack bobbins or cops are placed in their position just under the cotton friction or cleaner rail. The yarn passes from the cop or jack bobbin through the inside curl of the double quirl guide wire, is wound two or three times around the wire as the ten-



REEL FOR WINDING YARN INTO SKEINS

Saco & Pettee Machine Shops

sion may require or the strength of the yarn permit; then through the outer curl, over the felt on the cotton friction rail, into the porcelain pot eye guide, through the scraper guide, up to the porcelain guide attached to the friction cup on the screw spindle; then thrown around the cloth covered part of the winder bobbin to which it clings and thereby gets its start. When the yarn has builded the bobbin to the required diameter at its base the yarn will rub against the cup, Fig. 7, move it around and up on the screw spindle; as the yarn guide is attached to the cup, the yarn is raised with it and consequently does not wind on the bobbin as far down on its next descent with the building rail when this operation is repeated. The cup, and the yarn with it, moves up gradually until the bobbin is full to the top of the spindle leaving the top in the shape of a cone just as it has builded it all the way up. It takes its form from the conical shape of the empty bobbin at its base, shown at Fig. 2, and is made to build in that manner because the yarn comes off the bobbin in the most approved manner for knitting machine purposes.

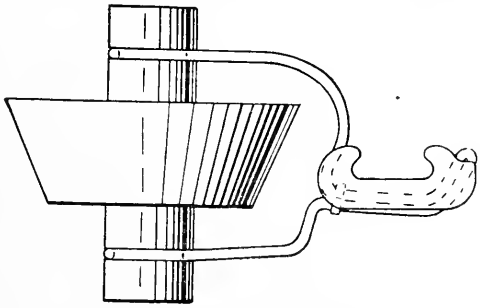


Fig. 7. Cup and Thread Guide.

The screw on which the cup moves is a ratch screw thread, flat on the upper side and V shaped on the lower; the cup is not tapped out but has a blade held in place by means of a spring, and meshing into the screw thread. This permits of the cup being raised with the thread or, in case of a bunch or large place on the bobbin, to slip up an extra tooth or be quickly raised out of harm's way in case of accident. When the bobbin is filled the cup is easily lowered to the starting point by a slight pressure of the thumb on a small lever on the blade while grasping the cup in the same hand.

Endwise Motion. The cotton friction, or cleaner-rail, has pieces of felt or flannel about three inches wide, attached to that part over which the yarn runs, to make friction, thereby increas-

ing the tension and incidentally helping to cleanse the yarn. In order that the yarn may not run in one crease on the felt the rail is made to move slowly endwise back and forth, and to oscillate a little; the latter motion is imparted by the suitably connected rockshaft levers.

The mechanism for imparting the endwise motion, Fig. 8, is attached to the building rail on the receiving pulley end of the machine from which it gets its movement. The friction rail is supported at each end by trunnions on which it oscillates. These trunnions are made long to allow for the endwise movement in their bearings, with extra length on the end that carries the endwise mechanism. A ratchet wheel turning on the trunnion is

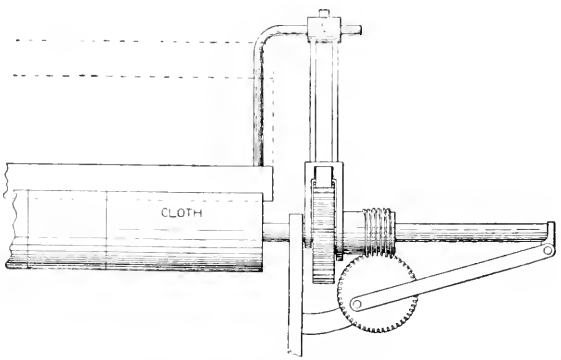


Fig. 8. Endwise Motion.

connected with the building rail and turns it with a worm gear running on the same trunnion. The worm causes to revolve a wheel gear to which is attached a rod connecting it with the cotton friction rail in a manner to impart to it a slow motion back and forth. These two motions prevent wearing the friction felts in only one place and thus assists in cleansing the yarn.

The Stop Motion is directly under that part of the bottom of the winder bobbin that projects over the flange, and is operated by pulling out the wire with a round eye that projects just beyond and below the rails beside and near the top of the cop (see Fig. 1). This action raises the winder bobbin from the flange and prevents it from revolving. Each bobbin has its own stop motion and consequently any bobbin may be stopped without stopping

any of the others. As the building cup of each bobbin is also independent, one may be partially or almost filled and another just being started. The building cup also adjusts itself to fine or coarse yarns so that several numbers can be wound at the same time if required.

The Tension is regulated to draw loosest on woolen yarn at the largest part of the bobbin and to tighten gradually as the yarn nears the smallest part or nose, because the larger the diameter the faster the yarn travels and vice-versa. To help regulate this matter a rail, with a porcelain pot eye guide for each thread, between and nearly on a level with the cotton friction rail and the cup rail, is supported by connections with the ball lever rock-shafts at such a point as to give a certain amount of rise to the pot-eye guide.

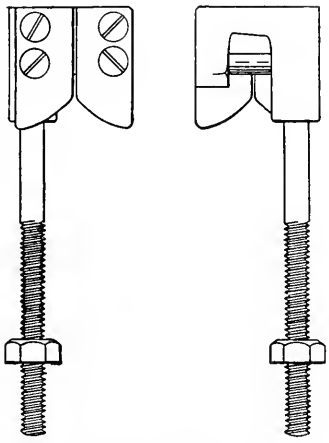


Fig. 9. Scraper Guide.

The Scraper Guide, Fig. 9 is stationary. It is a small casting having on the front side two blades, one adjustable. Between these blades the yarn passes, and as the slot between is adjusted to about the size of the yarn they act as a cleanser. If any foreign substance such as straws and seeds adhere to the yarn or lumpy places appear, the scraper helps to remove them. On the back of the scraper a porcelain guide is secured in the casting. When the yarn is being wound around the largest part of the bobbin the pot eye rail is at its lowest point; as the yarn builds higher on the bobbin the pot eye guide rail rises and gradually increases the tension by making a sharper angle between itself and the scraper guide, thereby increasing the friction on the yarn.

The Evans Friction Cone Drive is oftentimes applied to Winders to equalize the speed of winding, and by this means wind as fast at the small end or nose of the bobbin as at the large end or base. The cone drive is shown in Fig. 10 (Winder with Cone Drive). It has an automatic shipper X connected

with the rockshaft arm of the building motion and so arranged that the bobbin runs at its lowest speed when the yarn is being wound on its largest diameter and increases its speed in proportion to the decrease of its diameter, so that the yarn runs at the same speed and with more even tension. The leather friction band C is shipped from end to end of the cone A B by the auto-

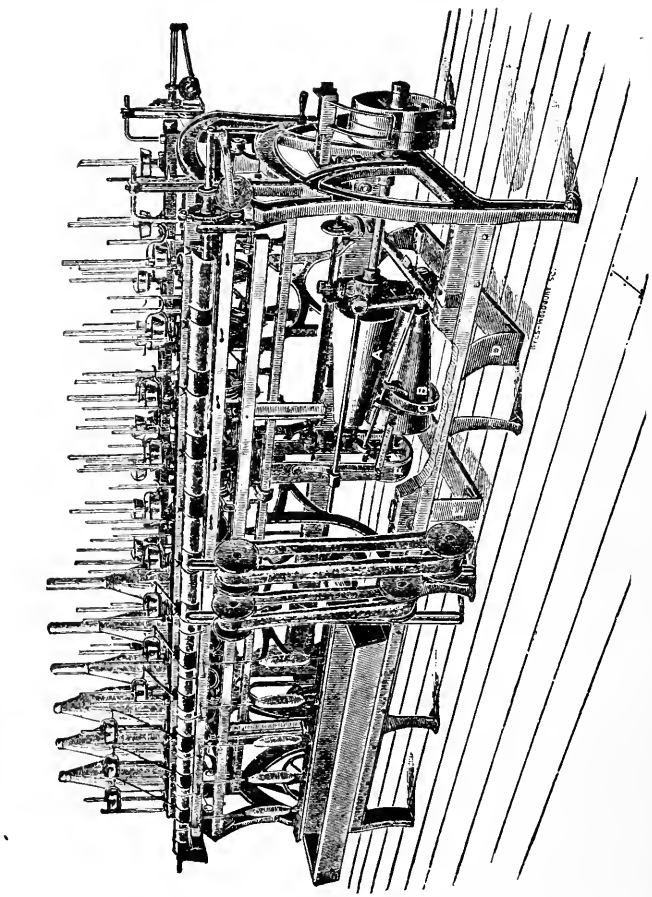
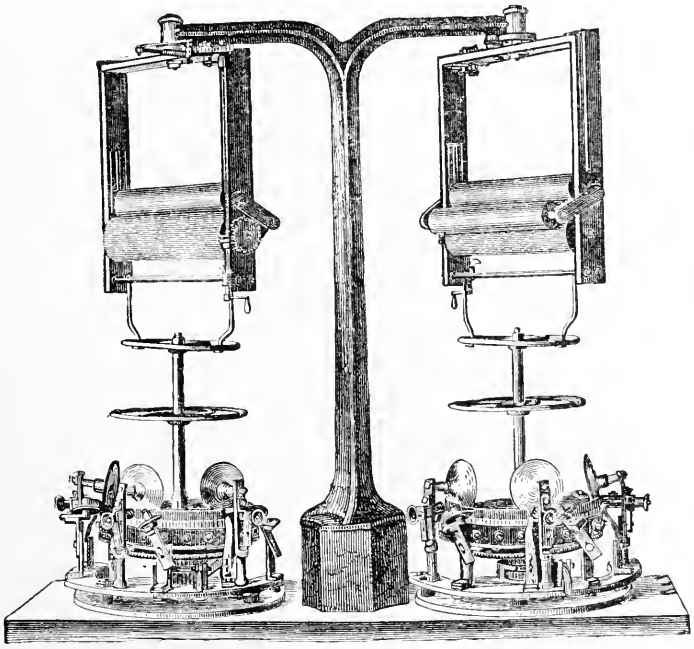


Fig. 10. Winder With Cone Drive.

matic shipper X. The cones should be carefully adjusted so that the pressure on the leather friction band, when the cones are at rest, is not so hard but what the band could be pulled through by hand, but not so loose that the friction is not sufficient to transmit the power. The cones may be forced together so hard that

the leather friction band will not transmit the power it should with proper tension. Too much pressure will make the winder run hard and cause trouble with the winding and is entirely unnecessary. One edge of the leather friction band should not be allowed to stretch more than the other and will not if the cones are kept the same distance apart at each end. This distance may be adjusted by means of check nuts just beneath the bearings at each end of the shaft on the lower or driven cone. If the above directions are followed carefully the cone drive will help the winder to build a more evenly uniform bobbin and build it quicker with less breaking of the yarn in the twits.



Old Type of Knitting Table.

KNITTING YARN TABLES AND CALCULATIONS.

The methods of designating the weight of mule spun yarn varies in different localities. The custom in the Cohoes Mills is to designate the yarn by the weight in grains of three threads from one draw of the jack; that is, after the jack has run back and drawn the roving off the spools, spun it and run to the furthermost point from the drawing roll, which is about 6 feet 3 inches, take three threads (from the spindle to the drawing rolls) break them off, and weigh them together. The weight in grains of these three threads, about 6¼ yards in length, is the "grain of the yarn." For instance, if these three threads weigh 11½ grains, the yarn is classified as 11½ grain yarn.

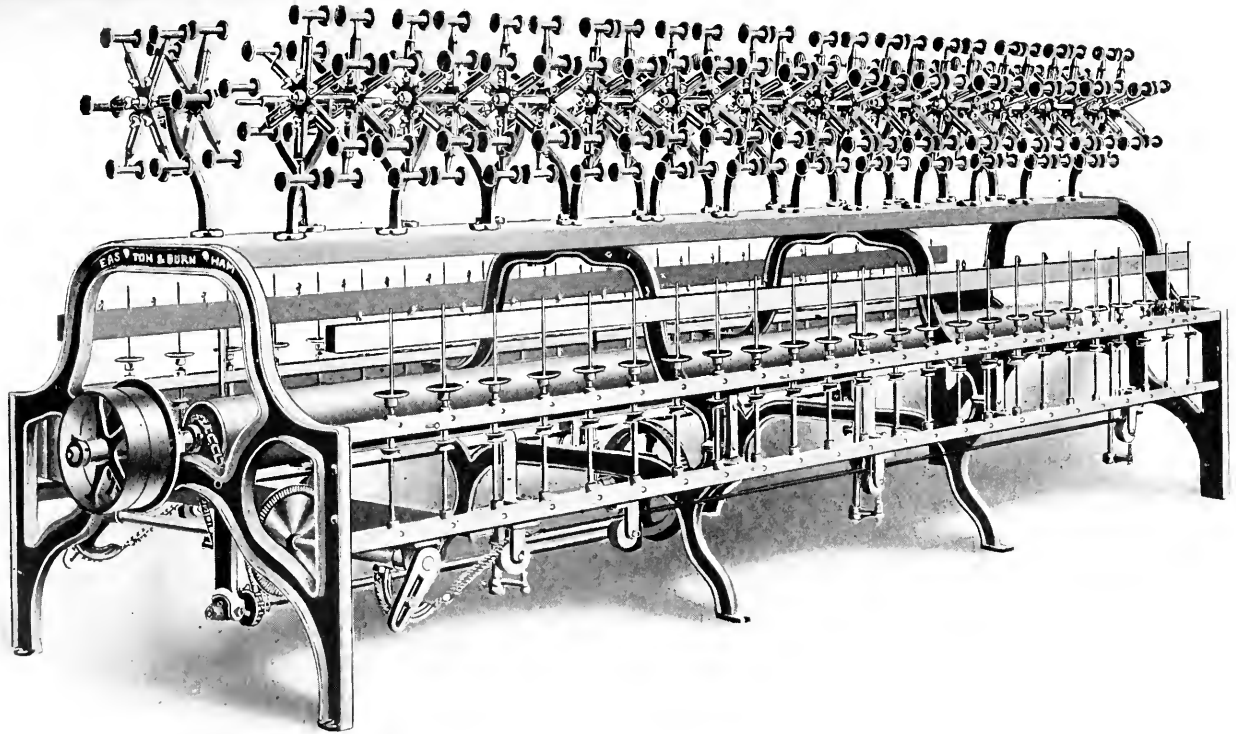
The Amsterdam method is to take 6 draws. This gives a closer weighing than the "three end" method but of course, the classification is twice as great. For instance, 11½ grain yarn Cohoes standard is 23 grain yarn Amsterdam standard.

The weight of yarn suitable for any particular gauge is determined for a maximum by the weight that can be crowded between the needles without causing bad work, and for lesser weights by the weight of the fabric required. For instance, on an 18 gauge machine 9¼ grain (Cohoes standard) yarn is about as heavy as is advisable, and a (12 pound to the dozen) No. 40 shirt may be made with it. Less grain yarn may be used for lighter garments.

Appended is a table giving the size of yarn in grains for the commonly used gauges and the corresponding weight per dozen of No. 40 shirts.

Gauge.	Grains in six draws.	Grains in three draws.	Weight per doz. of No. 40 Shirts.
24	9½	4¾	8¼
22	11	5½	9
20	14	7	11
18	18½	9¼	11½
16	21½	10¾	12
14	23	11½	12
12	27	13½	12
10	30	15	12½

As there are various systems of numbering yarn used in different localities, the following comparative tables are given.



SKEIN WINDER EQUIPPED WITH SPIDER SWIFT

Easton & Burnham Machine Co.

COMPARATIVE YARN TABLES. EQUIVALENTS OF DIFFERENT YARN STANDARDS.

New Hampshire Standard, 50 yds. in grains.	Yds. per lb. (7,000 grains).	Yds. per ounce (437.5 grains).	Cohoes Standard, weight of 6¼ yds. in grains.	Cuts 300 yds. per lb. per No.	Runs 1600 yards per lb. per No.	Cotton, 840 yds. per lb. per No.	Worsted, 560 yds. per lb. per No.
1166.67	300	18.75	145.83	1			
625.	560	35.	78.13				1
583.33	600	37 5	72.92	2			
416.66	840	52.5	52.08			1	
388.89	900	56.25	48.61	3			
312.5	1120	70.	39.06				2
291.67	1200	75.	36.46	4			
233.33	1500	93.75	29.17	5			
218.75	1600	100.	27.34		1		
208.33	1680	105.	26.04			2	3
194.44	1800	112.5	24:31	6			
166.66	2100	131.25	20.83	7		2½	3¾
156.25	2240	140.	19.53				4
145.83	2400	150.	18.23	8	1½		
138.89	2520	157.5	17.36			3	4½
129.63	2700	168.75	16.20	9			
125.	2800	175.	15.63		1¾		5
116.66	3000	187.5	14.58	10			
109.38	3200	200.	13.67		2		
106.06	3300	206.25	13.26	11			
104.17	3360	210.	13.02			4	6
97.22	3600	225.	12.15	12	2¼		
89.74	3900	243.75	11.22	13			
87.86	3920	245.	10.98				7
83.33	4200	262.5	10.42	14		5	7½
78.13	4480	280.	9.77				8
77.77	4500	281.25	9.72	15			
72.92	4800	300.	9.12	16	3		
69.44	5040	315.	8.68			6	9
68.63	5100	318.75	8.58	17			
64.82	5400	337.5	8.10	18			
62.50	5600	350.	7.81		3½		10
61.40	5700	356.25	7.68	19			
59.52	5880	367.5	7.44			7	10½
58.33	6000	375.	7.29	20	3¾		
56.82	6160	385.	7.10				11
55.56	6300	393.75	6.95	21		7½	11¼
54.69	6400	400.	6.84		4		
53.03	6600	412.5	6.63	22			
52.08	6720	420.	6.51			8	12
50.72	6900	431.25	6.34	23			
48.61	7200	450.	6.08	24	4½		
48.08	7280	455.	6.01				13
46.67	7500	468.75	5.83	25			
46.30	7560	472.5	5.79			9	
44.85	7800	487.5	5.61	26			
44.64	7840	490.	5.58				14
43.75	8000	500.	5.47		5		
43.21	8100	506.25	5.40	27			
41.67	8400	525.	5.28	28	5¼	10	15
40.23	8700	543.75	5.03	29			
39.06	8960	560.	4.88				16
38.88	9000	562.5	4.86	30			
37.88	9240	577.5	4.74			11	16½
37.63	9300	581.25	4.70	31			
36.76	9520	595.	4.60				17
36.46	9600	600.	4.56	32	6		
35.35	9900	618.75	4.42	33			
34.72	10080	630.	4.34			12	18
34.31	10200	637.5	4.29	34			
33.33	10500	656.25	4.17	35		12½	18¾
32.89	10640	665.	4.11				19
32.41	10800	675.	4.05	36	6¾		
31.25	11200	700.	3.91		7		20
29.76	11760	735.	3.72			14	21
29.16	12000	750.	3.65	40	7½		
28.41	12320	770.	3 55				22
27.78	12600	787.5	3.47			15	22½
27.34	12800	800.	3.42		8		
26.04	13440	840.	3.26			16	24
25.90	13500	843.75	3.24	45			
24.51	14280	892.5	3.06			17	25½
24.31	14400	900.	3.04	48	9		
24.04	14560	910.	3.01				26
23.33	15000	937.5	2.92	50			
23.15	15120	945.	2.89			18	27
22.44	15600	975.	2 81	52	9¾		
21.93	15960	997.5	2.74			19	28½
21.88	16000	1000.	2.74		10		
21.21	16500	1031.25	2.65	55			
20.83	16800	1050.	2.60	56	10½	20	30
19.89	17600	1100.	2.49		11		
19.53	17920	1120.	2.44				32
19.44	18000	1125.	2.43	60	11¼		
18.91	18480	1155.	2.37			22	33
18.38	19040	1190.	2.30				34
18.23	19200	1200.	2.28		12		
17.95	19500	1218.75	2.24	65			
17.36	20160	1260.	2.17			24	36
16.83	20800	1300.	2.10		13		
16.67	21000	1312.5	2.08	70		25	37½
16.45	21280	1330.	2.06				38
16.03	21840	1365.	2.00			26	39
15.63	22400	1400.	1.95		14		40
15.56	22500	1406.25	1.94	75			
14.88	23520	1470.	1.86			28	42
14.58	24000	1500.	1.82	80	15		
14.20	24640	1540.	1.78				44
13.89	25200	1575.	1.74	84	15¾	30	45
13.73	25500	1593.75	1.72	85			
13.67	25600	1600.	1.71		16		
13.59	25760	1610.	1.70				46
13.02	26880	1680.	1.63			32	48
12.97	27000	1687.5	1.62	90			
12.87	27200	1700.	1.61		17		
12.28	28500	1781.25	1.54	95			
12.25	28560	1785.	1.53			34	51
12.15	28800	1800.	2.77	98	18		
11.67	30000	1875.	1.46	100	18¾		
11.57	30240	1890.	1.45			36	54
11.51	30400	1900.	1.44		19		
10.96	31920	1995.	1.37			38	57
10.94	32000	2000.	1.37		20		
10.42	33600	2100.	1.30	112		40	60

Woolen Run System. Only the most delicate scales should be used for weighing yarn. Fig. 11 shows the kind of scale generally used for this work. The beam is graduated into 100 parts, indicating grains. Four weights, 100, 200, 400 and 800 grains, are furnished with the scale, and appended is a table giving the weights of fifty yards of many numbers of single woolen yarn, in grains. This table is obtained by the following calculation.

If 1,600 yards Single Woolen Yarn (called 1 Run) weigh 7,000 grains, (1 lb.) then one yard will weigh $\frac{1}{1600} \times 7000$ grains $= 4\frac{3}{8}$ grains, and 50 yards will weigh $50 \times 4\frac{3}{8}$ grains $= 218\frac{3}{4}$ grains. If 50 yards single Woolen 1 Run Yarn weigh $218\frac{3}{4}$ grains, 50 yards Single Woolen 2 Run Yarn will weigh $\frac{1}{2} \times 218\frac{3}{4}$ grains $= 109\frac{3}{8}$ grains and so on as per following table.

Weight in Grains, 50 Yards, Single Woolen Yarn in "Runs."

Run.	Grains.	Run.	Grains.
$\frac{1}{2}$	$437\frac{1}{2}$	$5\frac{1}{2}$	$39\frac{7}{22}$
$\frac{5}{8}$	350	$5\frac{3}{4}$	$38\frac{1}{23}$
$\frac{3}{4}$	$291\frac{2}{3}$	6	$36\frac{1}{24}$
$\frac{7}{8}$	250	$6\frac{1}{4}$	35
1	$218\frac{3}{4}$	$6\frac{1}{2}$	$35\frac{17}{36}$
$1\frac{1}{8}$	$194\frac{1}{9}$	$6\frac{3}{4}$	$32\frac{11}{27}$
$1\frac{1}{4}$	175	7	$31\frac{1}{4}$
$1\frac{3}{8}$	$159\frac{1}{11}$	$7\frac{1}{4}$	$30\frac{6}{29}$
$1\frac{1}{2}$	$145\frac{5}{6}$	$7\frac{1}{2}$	$29\frac{1}{8}$
$1\frac{5}{8}$	$134\frac{8}{13}$	$7\frac{3}{4}$	$28\frac{7}{31}$
$1\frac{3}{4}$	125	8	$27\frac{11}{32}$
$1\frac{7}{8}$	$116\frac{2}{3}$	$8\frac{1}{2}$	$25\frac{25}{34}$
2	$109\frac{3}{8}$	9	$24\frac{1}{36}$
$2\frac{1}{4}$	$97\frac{2}{9}$	$9\frac{1}{2}$	$23\frac{1}{38}$
$2\frac{1}{2}$	$87\frac{1}{2}$	10	$21\frac{7}{8}$
$2\frac{3}{4}$	$79\frac{6}{11}$	$10\frac{1}{2}$	$20\frac{35}{42}$
3	$72\frac{11}{12}$	11	$19\frac{39}{44}$
$3\frac{1}{4}$	$67\frac{1}{13}$	$11\frac{1}{2}$	$19\frac{1}{46}$
$3\frac{1}{2}$	$62\frac{1}{2}$	12	$18\frac{11}{48}$
$3\frac{3}{4}$	$58\frac{1}{3}$	$12\frac{1}{2}$	$17\frac{1}{2}$
4	$54\frac{11}{15}$	13	$16\frac{13}{52}$
$4\frac{1}{4}$	$51\frac{8}{17}$	$13\frac{1}{2}$	$16\frac{11}{54}$
$4\frac{1}{2}$	$48\frac{11}{18}$	14	$15\frac{5}{8}$
$4\frac{3}{4}$	$46\frac{9}{19}$	$14\frac{1}{2}$	$15\frac{5}{58}$
5	$43\frac{3}{4}$	15	$14\frac{7}{12}$
$5\frac{1}{4}$	$41\frac{2}{3}$		

Reel off 50 yards, and opposite its weight of grains in the table will be found its number or run of the yarn.

It often happens that it is necessary to ascertain the count from a small sample of yarn that measures but a few inches in

length. This may be done by very carefully measuring the length of the yarn, and weighing it as accurately as possible. Then apply the following rule, viz.: Divide the weight by the length in inches and multiply the quotient by 1800. Refer to the table above for the count or Run.

Example: Suppose 30 inches of Single woolen yarn weigh 4.19 grains. Then 4.19 ÷ 30 = .1396 × 1800 = 251.28. Referring to the table we find that the sample is $\frac{7}{8}$ Run Yarn, a trifle heavy, as the Standard for $\frac{7}{8}$ Run Single Woolen Yarn is 250 grains for fifty yards.

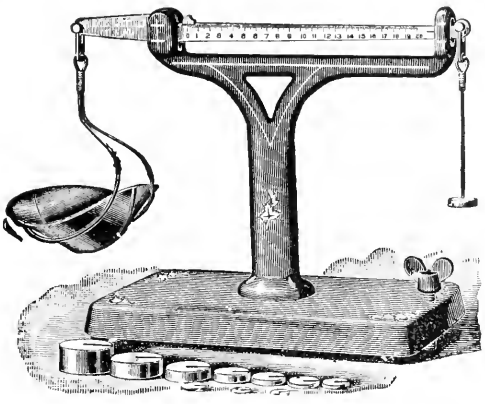


Fig. 11. Yarn Scales.

Again, suppose that we have 69 inches of Single woolen yarn that weigh 4.19 grains.

Then 4.19 ÷ 69 = .06072 × 1800 = 109.29.

Opposite this number in the table is the count, viz: 2 Run.

If the yarn is 2 Ply divide by 2.

" " " 3 " " " 3.

Again: — If 1,600 yards single woolen 1 Run Yarn weigh 7000 grains (1 lb.) then 1 yard will weigh $\frac{1}{1600} \times 7000 = 4\frac{3}{8}$ grains.

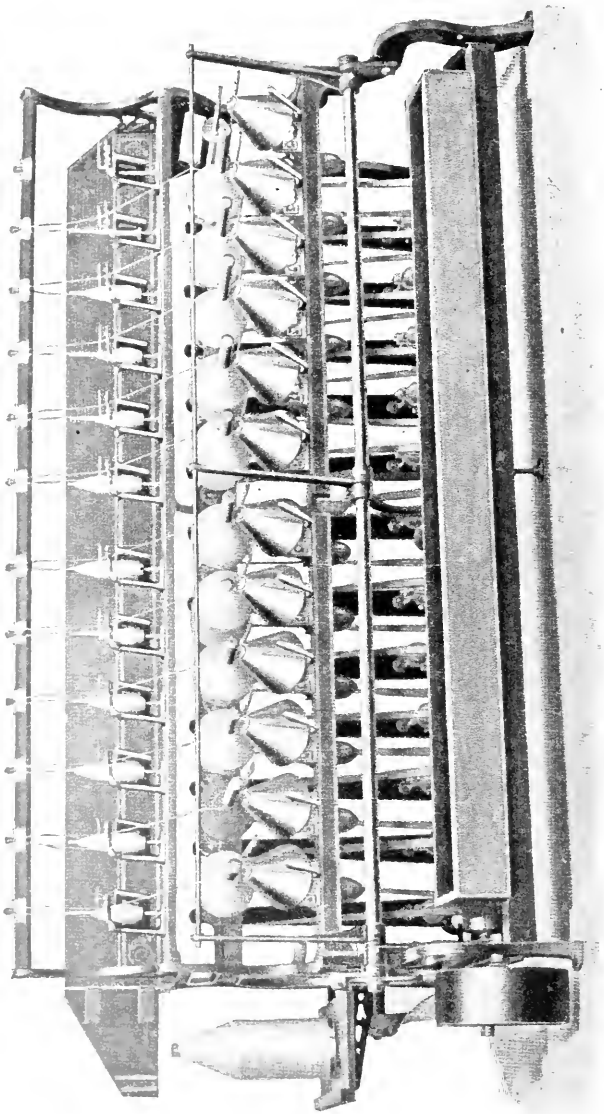
The number of yards weighing $4\frac{3}{8}$ grains is the same as the number of runs. For instance

1	yard	of	1	Run	Single	Woolen	Yarn	Weighs	$4\frac{3}{8}$	grains.
$1\frac{1}{4}$	"	"	$1\frac{1}{4}$	"	"	"	"	"	$4\frac{3}{8}$	"
$1\frac{1}{2}$	"	"	$1\frac{1}{2}$	"	"	"	"	"	$4\frac{3}{8}$	"
2	"	"	2	"	"	"	"	"	$4\frac{3}{8}$	"
$5\frac{1}{2}$	"	"	$5\frac{1}{2}$	"	"	"	"	"	$4\frac{3}{8}$	"
6	"	"	6	"	"	"	"	"	$4\frac{3}{8}$	"

And thus with all numbers between and so on.

Another way to find the number, or run, of woolen yarn is to reel or measure off and weigh any number of yards of the yarn

(the greater number of yards the more accurate the result); multiply the number of yards by $4\frac{3}{8}$ and divide the product by the



Revolving Cone Winder.

weight of the yarn in grains; the quotient will be the number of

runs per pound. For example: 9 yards weigh 5 grains, the $9 \times 4\frac{3}{8} = 39.375 \div 5 = 7\frac{7}{8}$ run, the count or number of the yarn. Or again, suppose 90 yards weigh 45 grains; $90 \times 4\frac{3}{8} = 393.75 \div 45 = 8\frac{3}{4}$ the number of run of the yarn.

Woolen cut System. If 300 yards Single Woolen 1 cut yarn weigh 7000 grains (1 lb. avoirdupois) then 1 yard will weigh $\frac{1}{300} \times 7000 = 23\frac{1}{3}$ grains and 50 yards will weigh $50 \times 23\frac{1}{3}$ grains $= 1{,}166\frac{2}{3}$ grains. Therefore, if 50 yards 1 cut Single Woolen Yarn weigh $1{,}166\frac{2}{3}$ grains, then 50 yards 2 cut will weigh one-half of $1{,}166\frac{2}{3}$ grains $= 583\frac{1}{3}$ grains.

Hence the following table: —

Weight in Grains 50 Yards any "Cut" Single Woolen Yarn.

50 yards	1-"Cut"	weigh	$1{,}166\frac{2}{3}$ grains	50 yards	20-"Cut"	weigh	$58\frac{1}{3}$ grains
50 "	2 "	"	$583\frac{1}{3}$ "	50 "	21 "	"	$55\frac{35}{63}$ "
50 "	3 "	"	$388\frac{8}{9}$ "	50 "	22 "	"	$53\frac{1}{33}$ "
50 "	4 "	"	$291\frac{2}{3}$ "	50 "	23 "	"	$50\frac{50}{69}$ "
50 "	5 "	"	$233\frac{1}{3}$ "	50 "	24 "	"	$48\frac{11}{18}$ "
50 "	6 "	"	$194\frac{4}{9}$ "	50 "	25 "	"	$46\frac{2}{3}$ "
50 "	7 "	"	$166\frac{2}{3}$ "	50 "	26 "	"	$44\frac{34}{51}$ "
50 "	8 "	"	$145\frac{5}{6}$ "	50 "	27 "	"	$43\frac{17}{51}$ "
50 "	9 "	"	$129\frac{17}{27}$ "	50 "	28 "	"	$41\frac{2}{3}$ "
50 "	10 "	"	$116\frac{2}{3}$ "	50 "	29 "	"	$40\frac{20}{87}$ "
50 "	11 "	"	$106\frac{2}{3}$ "	50 "	30 "	"	$38\frac{8}{9}$ "
50 "	12 "	"	$97\frac{2}{5}$ "	50 "	31 "	"	$37\frac{53}{93}$ "
50 "	13 "	"	$89\frac{29}{39}$ "	50 "	32 "	"	$36\frac{11}{24}$ "
50 "	14 "	"	$83\frac{1}{3}$ "	50 "	33 "	"	$35\frac{35}{99}$ "
50 "	15 "	"	$77\frac{7}{9}$ "	50 "	34 "	"	$34\frac{16}{51}$ "
50 "	16 "	"	$72\frac{11}{12}$ "	50 "	35 "	"	$33\frac{1}{3}$ "
50 "	17 "	"	$68\frac{12}{51}$ "	50 "	36 "	"	$32\frac{11}{27}$ "
50 "	18 "	"	$64\frac{2}{27}$ "	50 "	37 "	"	$31\frac{50}{111}$ "
50 "	19 "	"	$61\frac{23}{57}$ "	50 "	38 "	"	$30\frac{10}{57}$ "

Reel off 50 yards and opposite its weight in grains in the table will be found the cut.

For finding the cut of small samples the rule is the same as for the Run yarn, except that the above table must be used for finding the cut.

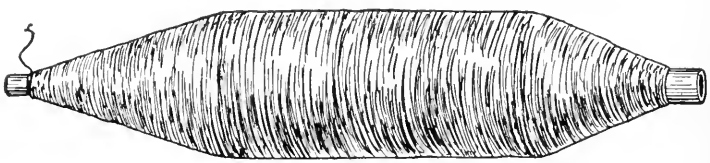
Example: Suppose 50 inches of single woolen yarn weigh 3.241 grains.

$$3.241 \div 50 = .06482 \times 1800 = 116.67$$

opposite that number in the table above, we find 10, which is the count or cut of the yarn.

The number of yards weighing $23\frac{1}{3}$ grains is the same always as the number, or cut: thus —

1 yard	Single	Woolen	Yarn	1	Cut	weighs	$23\frac{1}{3}$	grains.
2 yards	"	"	"	2	"	"	$23\frac{1}{3}$	"
3	"	"	"	3	"	"	$23\frac{1}{3}$	"
10	"	"	"	10	"	"	$23\frac{1}{3}$	"
30	"	"	"	30	"	"	$23\frac{1}{3}$	"



French Spun Worsted; Cop Form.

The Yarn Reel used in connection with the yarn scales, is like the one shown in Fig. 12. This yarn reel is 54 inches or one and one-half yards in circumference. The dial is graduated into 120 parts, and indicates the number of yards reeled from each spindle. The yarn guides and spindles are so arranged that they are kept in line with each other while feeding yarn on to the reel. The extra length of the yarn guides is of use in increasing the friction on the yarn by making a half turn or more around them. In order to lay the yarn flat upon the reel, an automatic feed motion is provided, by means of which accurate and uniform measurement is secured. Following is a table for numbering cotton, linen, and worsted yarns.

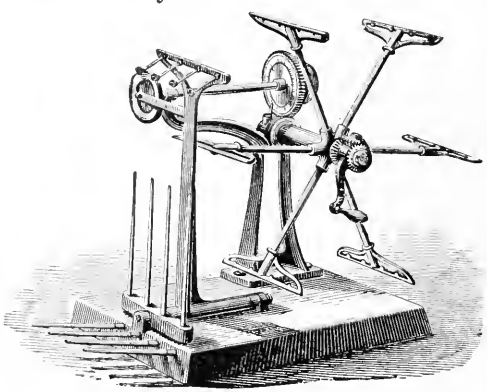
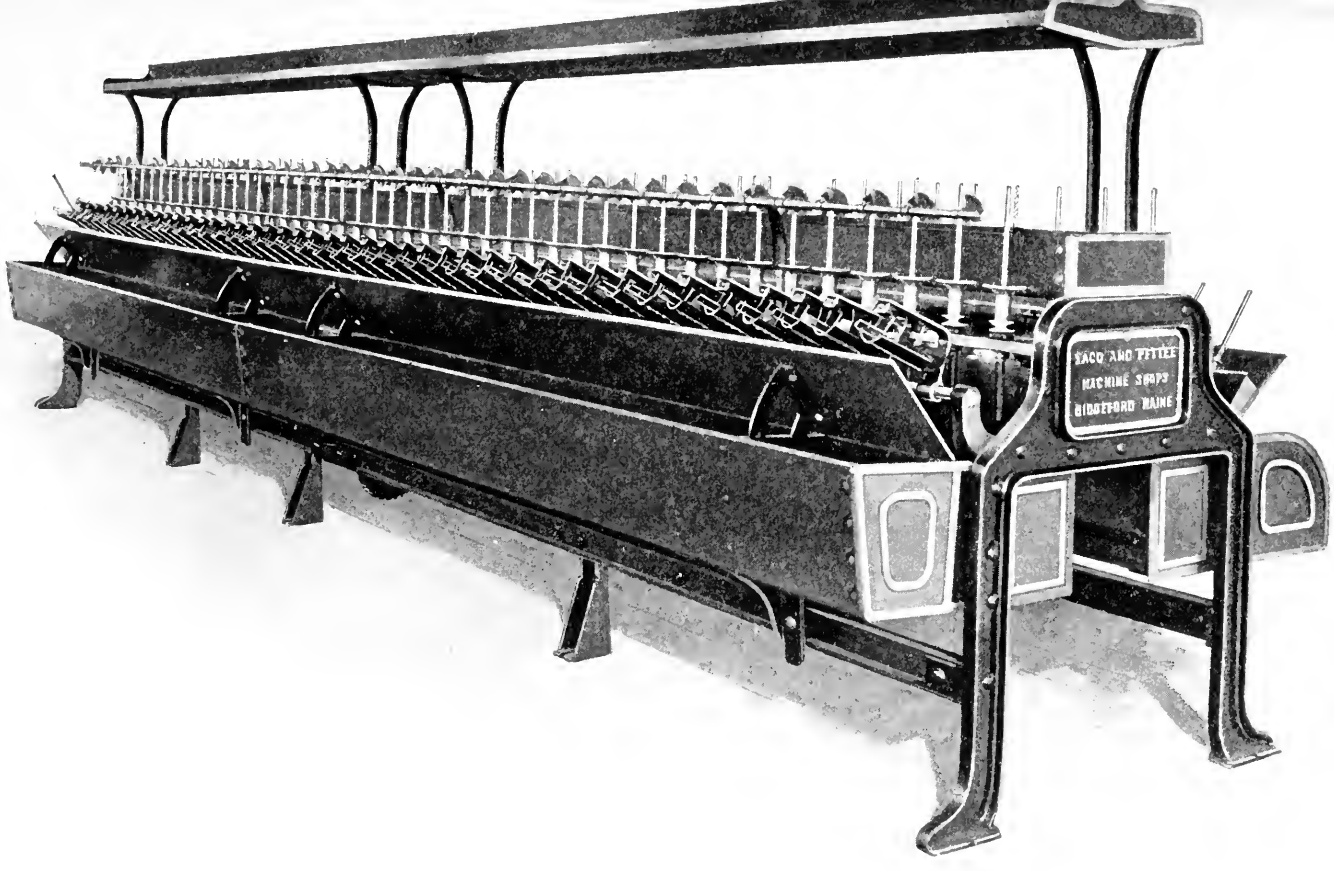


Fig. 12. Yarn Reel.



IMPROVED SPOOLER WITH CRADLE BOBBIN HOLDERS

Saco & Pettee Machine Shop

Table for Numbering Cotton, Linen and Worsted Yarns.

No.	Grains.	No.	Grains.	No.	Grains.	No.	Grains.	No.	Grains.
5	1400.	27	259.3	49	142.8	71	98.6	93	75.3
6	1166.6	28	250.	50	140.	72	97.2	94	74.5
7	1000.	29	241.5	51	137.3	73	95.9	95	73.7
8	875.	30	233.4	52	134.7	74	94.6	96	72 9
9	777.8	31	225.8	53	132.1	75	93.3	97	72.3
10	700.	32	218 8	54	129 7	76	92.1	98	71.4
11	636.4	33	212.2	55	127.3	77	90.9	99	70.7
12	583.3	34	206.	56	125.	78	89.7	100	70.
13	538.5	35	200.	57	122.8	79	88.6	105	66.7
14	500.	36	194.6	58	120.7	80	87 5	110	63.6
15	466.8	37	189.3	59	118 6	81	86.4	115	60.9
16	437.5	38	184 3	60	116 7	82	85.4	120	58.3
17	411.9	39	179.6	61	114 8	83	84.3	125	56.
18	389.	40	175.	62	112.9	84	83 3	130	53.8
19	368.5	41	170.8	63	111.1	85	82 4	135	51.8
20	350.	42	166.7	64	109.3	86	81.4	140	50.
21	333.3	43	162.8	65	107.7	87	80.4	145	48.3
22	318.3	44	159.2	66	106.1	88	79.5	150	46.7
23	304.6	45	155.6	67	104.4	89	78.6	155	45.2
24	292.8	46	152.2	68	102.9	90	77.8	160	43.8
25	280.	47	148.9	69	101.4	91	76.9	165	42.4
26	269.3	48	145.8	70	100.	92	79.1	170	41.2
								175	40.
								180	38.9
								185	37.8
								190	36.8
								195	35.9
								200	35.

To number cotton yarn: Reel 840 Yards, equal to one skein or hank, and opposite its weight of grains in the table, will be found its number.

To number linen yarn: Reel 300 yards, equal to one lea, and opposite its weight of grains in the table, will be found its number.

To number worsted yarn: Reel 560 yards, equal to one skein or hank, and opposite its weight of grains in the table, will be found its number.

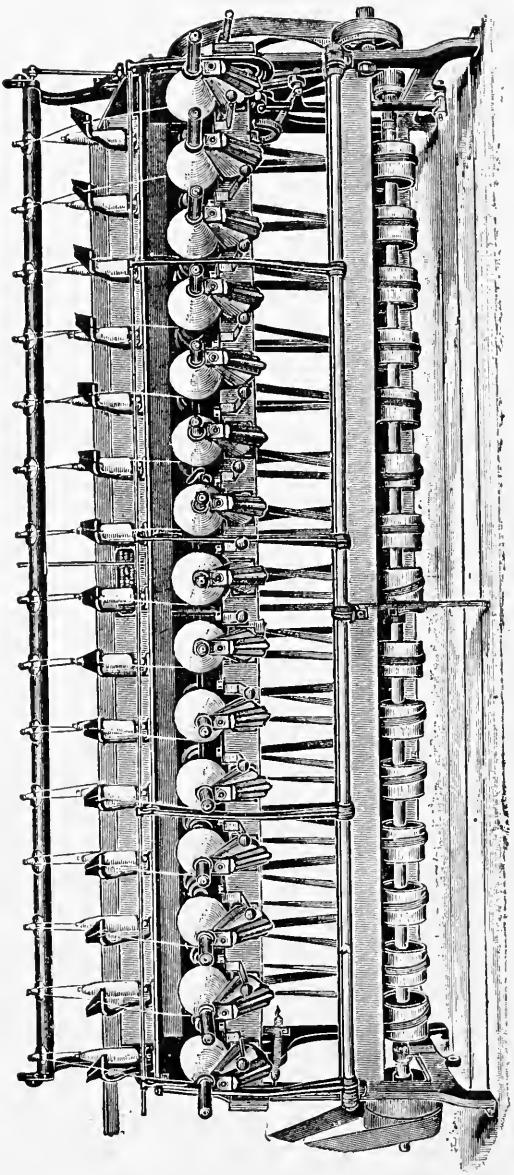
Worsted Count System. 560 yards No. 1 Worsted Yarn weigh 7000 grains (1 lb.)

50 yards of No. 1 Worsted Yarn weigh 625 grains, from which the table on page 25 is calculated.

Reel off 50 yards, and opposite its weight of grains in the table will be found the count or No. of the yarn.

To find the count from a small sample of single worsted yarn: Divide the weight by the length in inches and multiply the quo-

tient by 1800 (50 yards reduced to inches = 1800 inches). Find



Another Type of Cone Winder.

the number in the table on page 25 and opposite is the number designating the No. of the yarn.

Example : Suppose we have 52 inches of single worsted yarn weighing 6.02 grains: Then: $6.02 \div 52 = .1{,}157$, this $\times 1800 = 208.33$. Referring to the table we find that the size of this yarn is No. 3. Again; — Suppose we have 152 inches weighing 1.056 grains, then $1.056 \div 152 = .006947 \times 1800 = 12.505$; therefore, by referring to the table we find that the count is No. 50.

Weight in Grains 50 Yards. any No. Single Worsted Yarn.

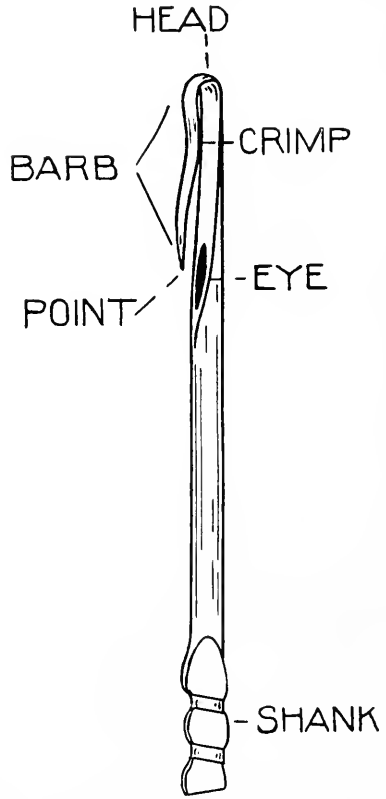
No.	Grains.	No.	Grains.	No.	Grains.	No.	Grains.
1	625.	26	24.03	51	12.25	76	8.22
2	312.5	27	23.14	52	12.01	77	8.11
3	208.33	28	22.32	53	11.79	78	8.01
4	156.25	29	21.55	54	11.57	79	7.91
5	125.	30	20.83	55	11.36	80	7.81
6	104.16	31	20.16	56	11.16	81	7.71
7	89.28	32	19.53	57	10.96	82	7.62
8	78.12	33	18.93	58	10.77	83	7.53
9	69.44	34	17.38	59	10.59	84	7.44
10	62.50	35	17.85	60	10.41	85	7.35
11	56.81	36	17.36	61	10.24	86	7.26
12	52.08	37	16.89	62	10.08	87	7.18
13	48.07	38	16.44	63	9.92	88	7.10
14	44.64	39	16.03	64	9.76	89	7.02
15	41.66	40	15.62	65	9.61	90	6.94
16	39.06	41	15.24	66	9.46	91	6.86
17	36.76	42	14.88	67	9.32	92	6:79
18	34.72	43	14.53	68	9.19	93	6.72
19	32.89	44	14.20	69	9.05	94	6.64
20	31.25	45	13.88	70	8.92	95	6.57
21	29.76	46	13.58	71	8.80	96	6.51
22	28.40	47	13.29	72	8.68	97	6.44
23	27.17	48	13.02	73	8.56	98	6.37
24	26.04	49	12.75	74	8.44	99	6.31
25	25.	50	12.50	75	8.33	100	6.25

CYLINDER SPRING NEEDLE MACHINES.

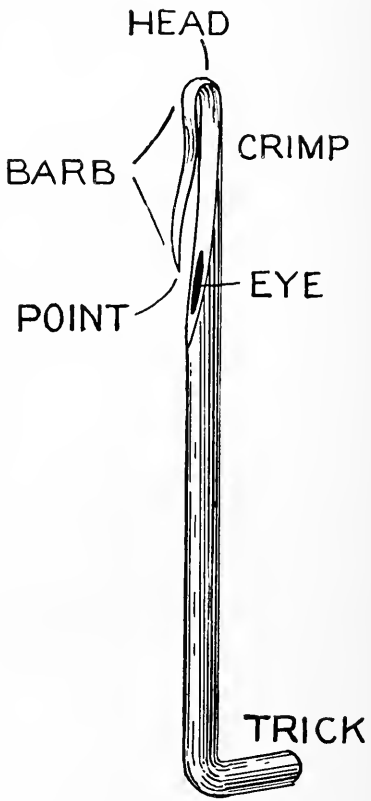
There are different types of this style of machine, the principles being about the same but differing in construction. They may be classified as to method of holding the needles — the *Leaded Needle* and the *Trick Needle;* as to the mode of driving the take-up — *Overhead Drive* and *Inside Drive;* — and as to the kind of fabric made — *Flat*, *Backing* and *Rib*. The leaded needle machine is the oldest type and in most general use.

Fig. 13 shows the Tompkins two cylinder leaded spring needle machine. The most prominent feature brought out in this engraving, besides the general outlines, are the rolls of cloth showing the direction they take from the needles, the take-up for roll-

ing up the cloth, the location of the winder bobbins and the feeds taking the yarn from the bobbins and feeding it to the needles. The needles are leaded in sections by placing in a mould specially made for the purpose which holds the needles securely in their proper position while the metal is run into it. The needles being in small sections or leads, two needles in a block, greatly facili-



Spring Needle (Unleaded) Actual Size.



Trick Needle.

tates the replacing of broken or worn needles as they are quickly and easily placed in position in the cylinder. It is a great mistake to neglect the needle moulds and leave them in the care of careless hands. If the moulds are abused and the needles made to go when they do not just fit, the cloth looks uneven and otherwise unsightly, the burs are difficult to set and smashes occur without any apparent reason.

The Needle Mould. Fig. 14, used in leading needles consists essentially of two side pieces, each having secured to its inner face a plate, and hinged by a bolt at one end. The side pieces form the sides of the mould and the adjacent edges of the plates form the

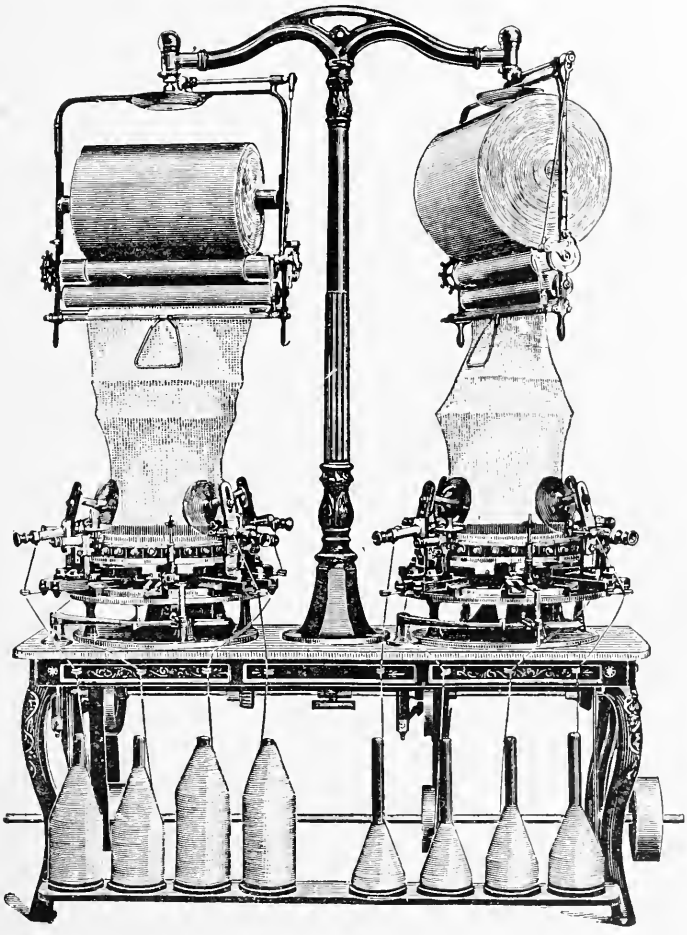


Fig. 13. Leaded Spring Needle Machine.

front and back faces of the mould. The sprue is drilled between the side pieces at the free ends, and the two needles, held heads outward by what is called a "trick" and grooves, project partially into the mould at the hinged end. A mixture of lead, antimony,

and tin that fuses readily but is quite hard when solid is poured into the mould, which is then opened, the lead with the embedded needles is withdrawn, the sprue is cut off and the leaded needles are ready to be clamped in the cylinder. One advantage of leaded needles is that the needle being held in the mould by the head and middle portion stands true in the lead and consequently in the cylinder. An objection is the bother with the mould, lead and needle boy. Faulty moulds will produce altogether too much trouble and annoyance to be tolerated, and the knitter who neglects them will never excel in the art of knitting.

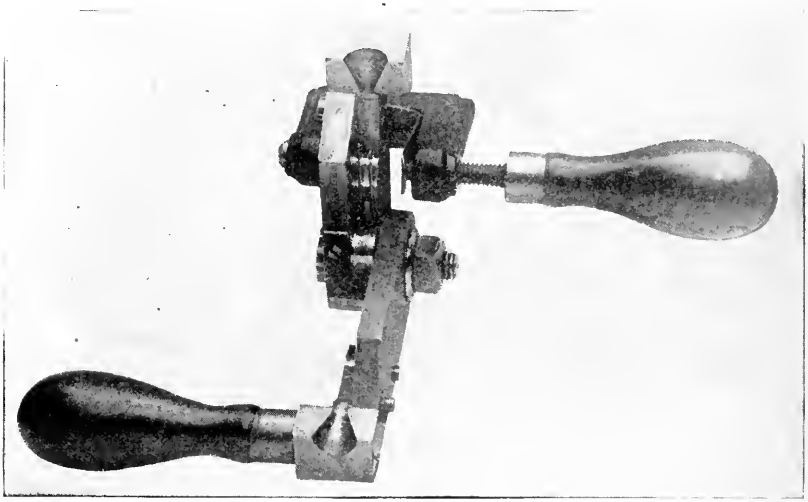
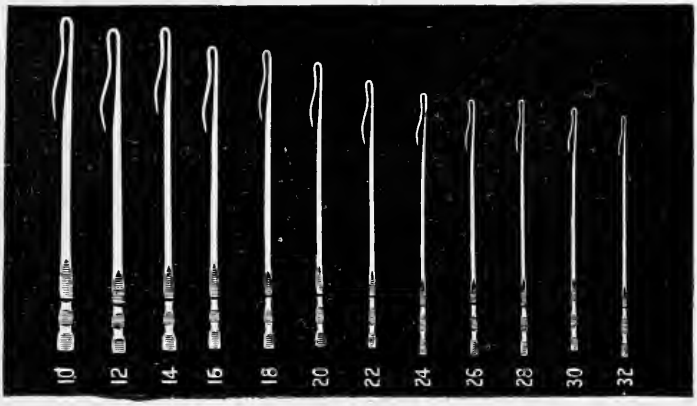


Fig. 14. Needle Mold.

Needles for backing work should be longer than for plain work, the object being to keep the sinker bur from picking up the backing. It also distributes the bending, caused by the backing bur, over a greater length of the needle and thereby prolongs the life of the needle.

The Gauge of a leaded needle cylinder can be changed by having a needle mould made for the gauge desired, or in a trick needle cylinder by having a new cylinder or trick-tops cut. The gauge determines the closeness of the wales of the cloth and the relative fineness of the fabric. The gauge is generally deter-

mined, in the old way, by the number of leads contained in three inches of the circumference of the cylinder. As each lead contains two needles it is sometimes the custom or habit to call the gauge the number of needles in an inch and a half, and other times to call it half the number of needles in three inches; but it is not good practice, though equivalent thereto. In some localities the gauge is the number of needles to the inch, and yet again in other localities, the number of needles in two inches. The difference in measuring cylinders by different makers, and the difference in measuring leaded needle cylinders and trick needle



Spring Needles Unleaded.

cylinders, is mostly responsible for this lack of uniformity in designating the relative degree of fineness of the fabric. The knitter governs himself, in the gauge matter, according to the type of machine he encounters, and the locality he finds himself in.

If by the old way (viz: the number of leads in three inches), and twenty gauge is required, there should be forty needles in three inches measured on the circumference of the cylinder ($13\frac{1}{2}$ needles to the inch). Or if fourteen gauge is required, there should be twenty-eight needles in three inches on the circumference ($9\frac{1}{3}$ needles to the inch).

If it be a 14 inch cylinder, the circumference will measure 43.98 inches and if it be 20 gauge on the needle line, there would

be 586 needles in the needle space around the cylinder. If it be a 22 inch cylinder, the circumference will measure 69.12 inches, and if it be a 22 gauge the needle space should contain 1014 needles.

The following table indicates sizes generally accepted: —

Gauge.	Needles to the Inch.	Stubbs Wire.	Size in Inches.
30	20	(24)	(.023 to)
		(23½)	(.0245)
		(23)	(.0255 to)
24	16	(22½)	(.0275)
22	14⅔	22	.029
20	13⅓	21	.0315
18	12	20	.0355
16	10⅔	19½	.039
14	9⅓	19	.0415

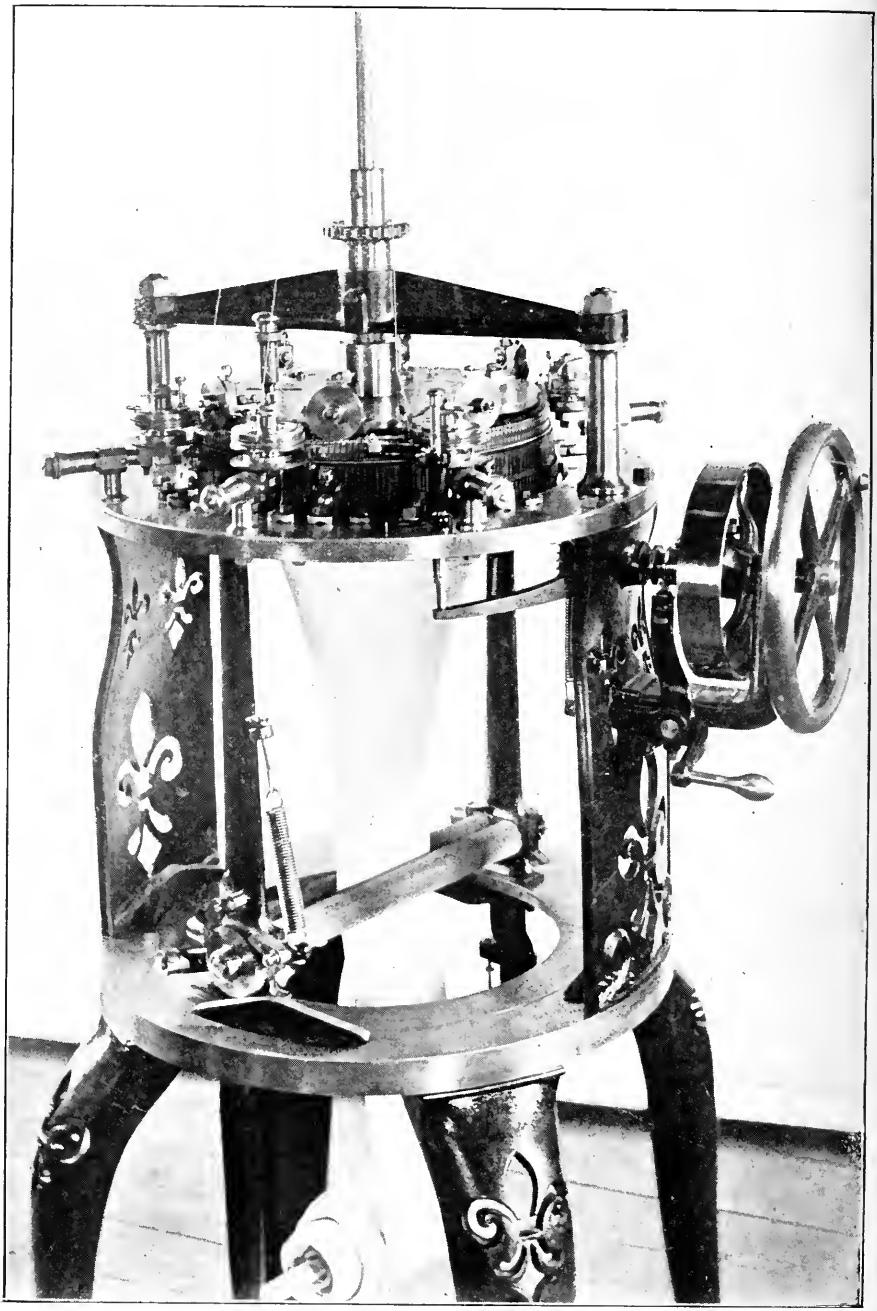
To reduce the old gauge to the number of needles to the inch; Multiply the gauge by ⅔; because the gauge is the number of leads in three inches, and there are two needles in a lead.

To find the number of needles to the inch, the whole number of needles in the machine being given and the diameter: Multiply the diameter by 3.14 and divide the number of needles by the product. For example: Given a cylinder 22 inches in diameter containing 1014 needles, how many needles are there to the inch? $22 \times 3.14 = 69.08$. $1014 \div 69.08 = 14\frac{2}{3}$ needles to the inch, and $14\frac{2}{3}$ is ⅔ of the gauge, or 22 gauge.

To find the number of needles required in the cylinder the number of needles to the inch as gauge being given, and the diameter of the cylinder: Multiply the diameter of the cylinder by 3.14 and multiply the product by the number of needles to the inch as gauge. For example: How many needles should there be in a cylinder 18 inches in diameter to knit 20 gauge cloth?

$18 \times 3.14 = 56.52 \times 13\frac{1}{3}$ (⅔ of the gauge 20 is $13\frac{1}{3}$ needles to the inch) = 754.

Following is a table giving circumferences of cylinders in inches from 6 to $35\frac{1}{2}$ inches in diameter:



SPRING NEEDLE RIB MACHINE EQUIPPED WITH STOP MOTION

Crane Mfg. Co.

Table of Circumferences of Cylinders in Inches and Feet.

Diameter of Cylinder. in Inches	Circumference of Cylinder in Inches.	Circumference of Cylinder in Feet.	Diameter of Cylinder in Inches.	Circumference of Cylinder in Inches.	Circumference of Cylinder in Feet.
6	18.85	1 57	24	75.40	6.28
6½	20.42	1.70	24½	76.97	6.41
7	21.99	1.83	25	78.54	6.55
7½	23 56	1.96	25½	80.11	6.68
8	25.13	2.09	26	81.68	6.81
8½	26 70	2.23	26½	83.25	6.94
9	28.27	2.36	27	84.82	7.07
9½	29.85	2.49	27½	86.39	7.20
10	31.42	2.62	28	87.97	7.33
10½	32.99	2.75	28½	89.54	7.46
11	34.56	2.88	29	91.11	7.59
11½	36.13	3.01	29½	92 68	7.72
12	37 70	3.14	30	94.25	7.85
12½	39.27	3.27	30½	95.82	7.99
13	40.84	3.40	31	97.39	8.12
13½	42.41	3.53	31½	98.96	8 25
14	43.98	3.67	32	100.53	8 38
14½	45.55	3.79	32½	102.10	8.51
15	47.12	3.93	33	103.67	8.64
15½	48.70	4.06	33½	105.24	8.77
16	50.27	4.19	34	106.21	8.90
16½	51.84	4.32	34½	108.39	9.03
17	53.41	4.45	35	109.96	9.16
17½	54.98	4.58	35½	111.53	9.29
18	56.55	4.71			
18½	58.12	4.84			
19	59.69	4 97			
19½	61.26	5.11			
20	62.83	5 24			
20½	64.40	5.37			
21	65.97	5.50			
21½	67.54	5.63			
22	69.12	5.76			
22½	70.69	5.89			
23	72.25	6.02			
23½	73.83	6.15			

The Method of Driving is with a belt attached to a pulley at the end of the table on the shaft, and at the bottom of the frame, that extends the length and projects at either end so that the receiving pulley may be driven from either end. On the shaft are two pulleys each driving a separate counter shaft — one for each cylinder — directly under the table. Each of these counters have a tight and loose pulley, for the cylinder is started and stopped with a shipper which is mounted on top of the table within easy reach of the operator, as is shown in detail in Fig. 15. On each counter is a bevel pinion that meshes with a bevel gear

driving the double pinion shown under the cylinder. The upper spur gear of the double pinion drives the cylinder and the lower half drives the center shaft — the vertical shaft shown in Fig. 16.

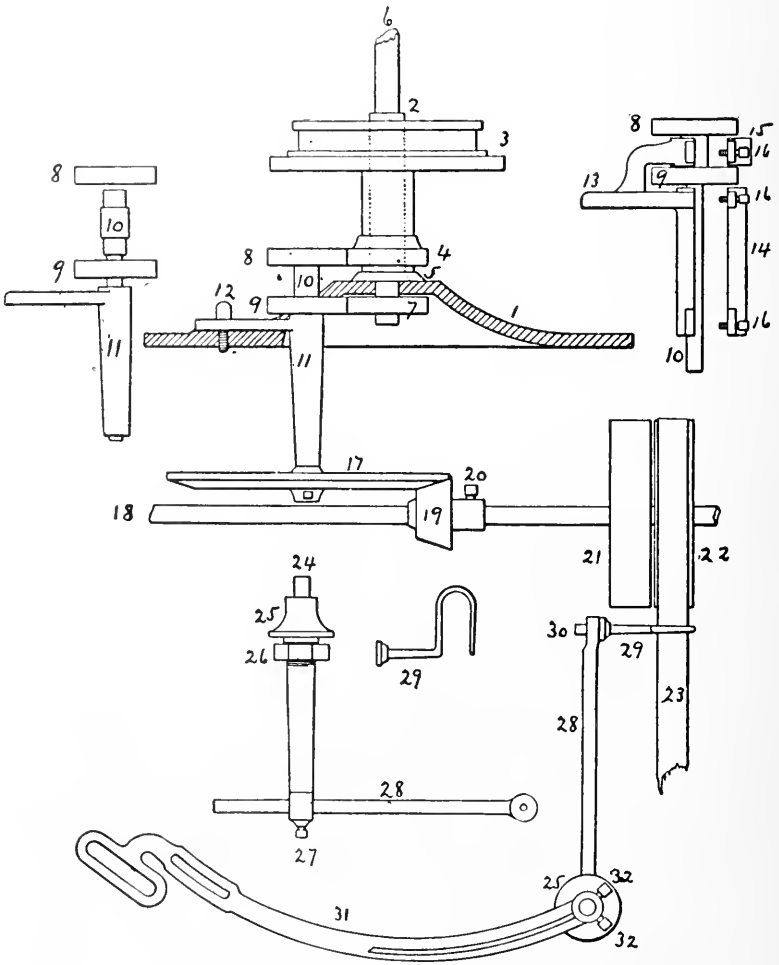


Fig. 15. Cylinder Drive.

The gear on the lower end of the vertical shaft is hidden by the bed plate, but is shown in detail in this illustration. This vertical shaft drives the take-up, revolves in the same direction as the cylinder and makes the same number of revolutions per minute.

The connections from the shipper to the cylinder and vertical shaft are shown in detail, and are thus explained: The shipper 31, is fastened to stud 24, which turns in sleeve 25, fastened to the guide 29, which throws the belt from tight to loose pulley or back at the will of the operator; the tight pulley drives the counter shaft 18, to which is fastened the bevel pinion 19, with set screw 20; bevel pinion 19, meshes with bevel gear 17, which drives shaft 10, at the upper end of which is fastened the double pinion 8 and 9, shaft 10, runs in sleeve or box 11, secured to the bed plate of the machine. Pinion 9, drives gear 7, which is fastened to vertical shaft 6, that drives the take-up; and pinion 8, drives gear 4, which drives the cylinder 3.

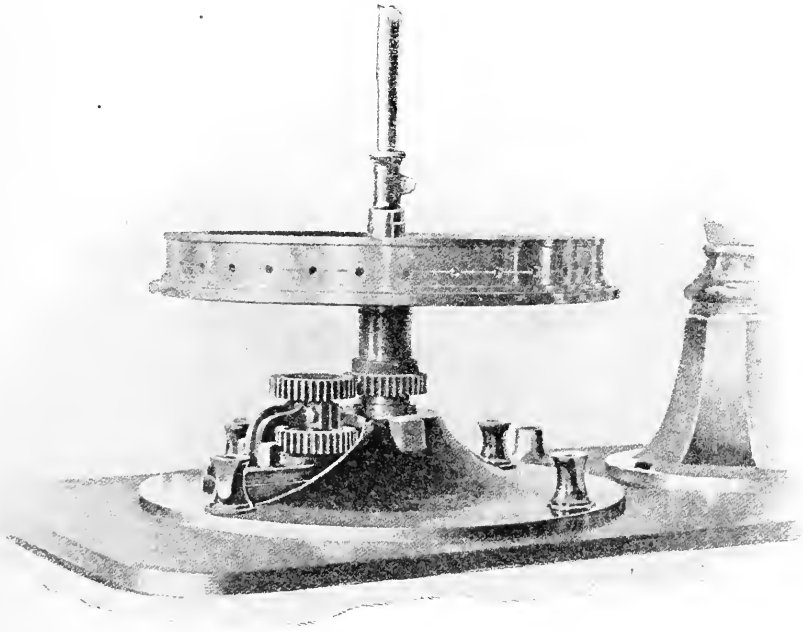


Fig. 16. Cylinder and Driving Gears.

The Cylinder. The cylinder is shown in detail in Figs. 16 and 17. The holes in the periphery of the cylinder are for the clamp screws to tighten the clamps that hold in place the leads containing the needles. The drawing on either side at the top of Fig. 15 show details of the double pinion and the bearing in which it runs.

The cylinder 1, is shown in two views — top and side; 2 is the spur gear which is fastened to the hub of the cylinder and drives it; 4 is the clamp for holding the leads; 6 the washer and 5 the clamp screw for tightening the clamps; 7 is an iron ring,

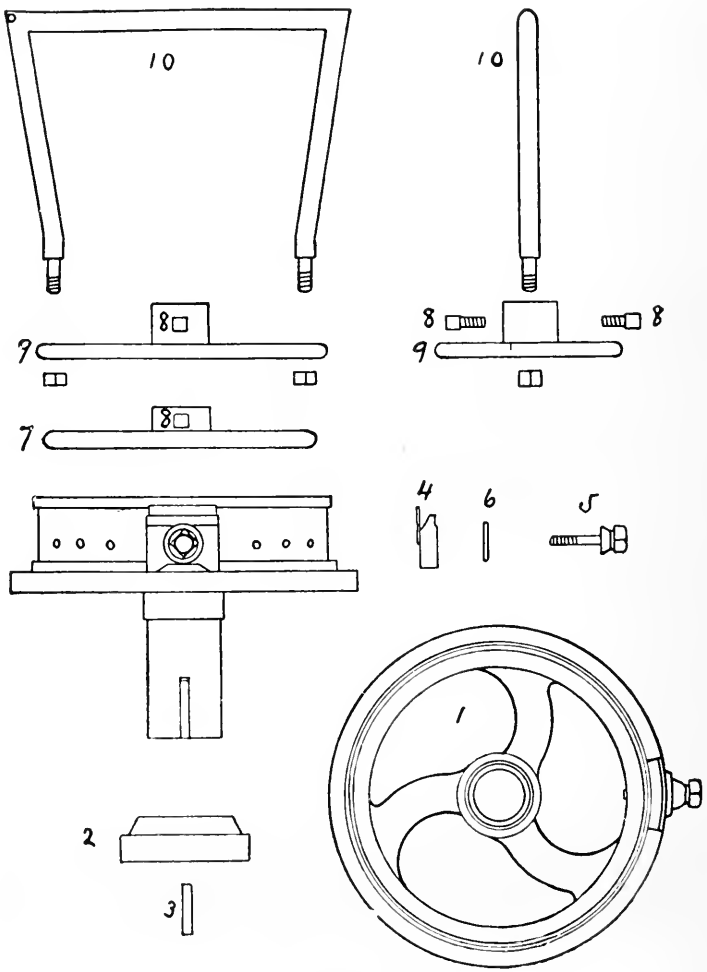
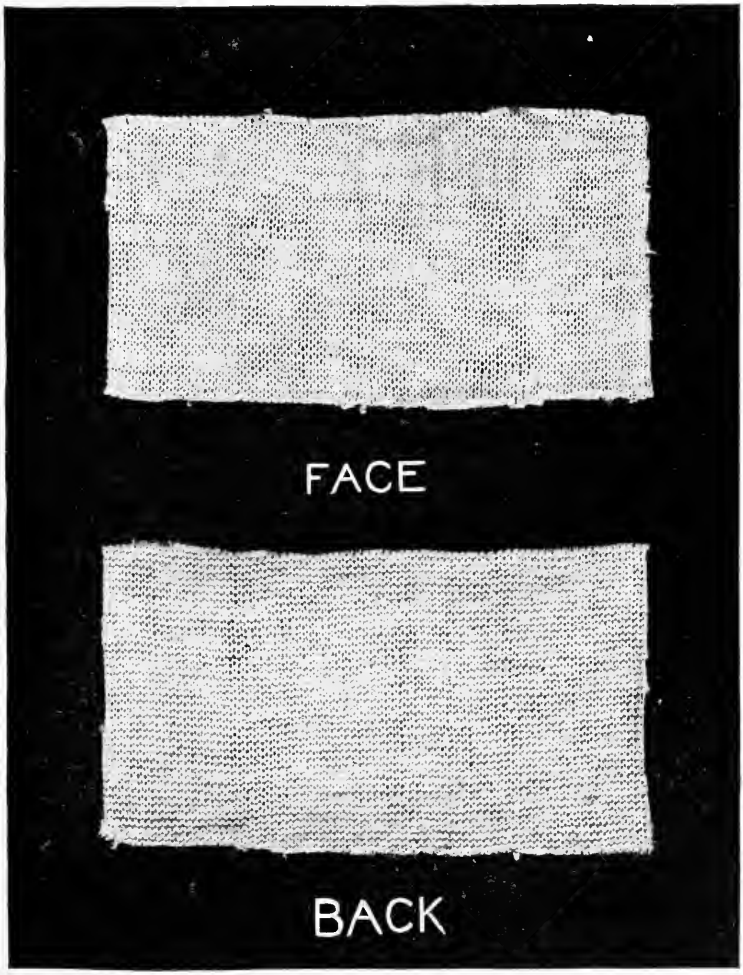


Fig. 17. Cylinder and Parts.

the bottom spreader, secured to the vertical shaft, and serves to keep the web in the cylindrical form in which it left the needles; 9 is an elliptical ring, the top spreader, also secured to the verti-

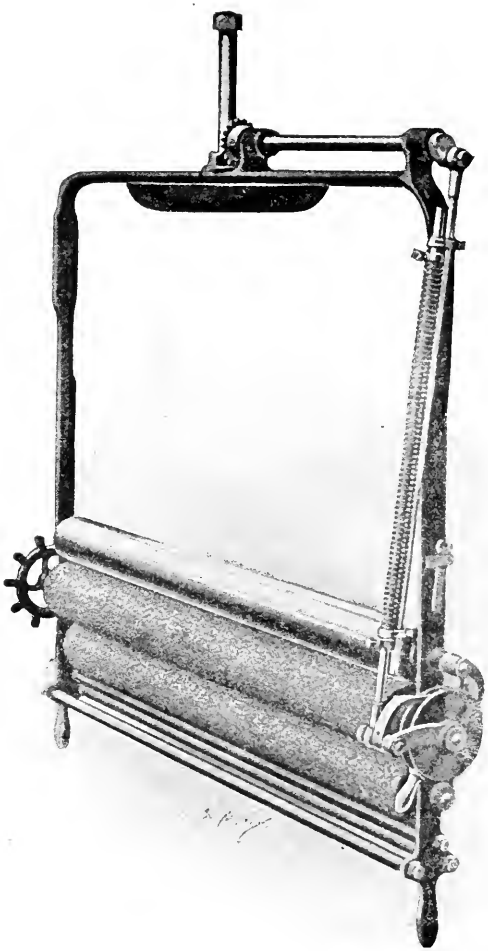
cal shaft which serves to guide the web to the winding or take-up rolls and present it in better shape to be rolled up on the rolls. Bottom spreader 7, being the same shape as the cylinder equal-



Light Weight Cotton Fabric, 18 Gauge.

izes the tension of the cloth on the needles at all points round the cylinder, while the top spreader 9, shapes and guides the web to the take-up rollers so that it is rolled up with the circular rows of

stitches or courses, in straight horizontal lines across the flattened fabric. To top spreader 9, is fastened the spreader bow 10, which is secured to the take-up and drives it. The drawing on the right and at the top of Fig. 17, is a side view of 9 and 10.



Elevation of Take-Up.

The Take-Up is an important adjunct to the knitting machine, whose function is to take away, or take-up, the web of cloth from the needles as fast as it is knitted, and maintain the proper degree

of tension on the needles. To take it up too slowly would cause an accumulation of yarn in the needles; to take it up too fast would cause a severe strain on the needles. The effects of either would be broken needles, a smash, uneven cloth and possibly a pull off. The take-up which is shown in Fig. 18 consists of three rollers contained in a frame with connecting mechanism to turn them in the required manner. It is suspended to the cross-tree extending from the top of the central column of the machine (see Fig. 13) by the stationary stud 8, (Fig. 18,) and is driven by the spreader bow inside of the web and between the two rods at the

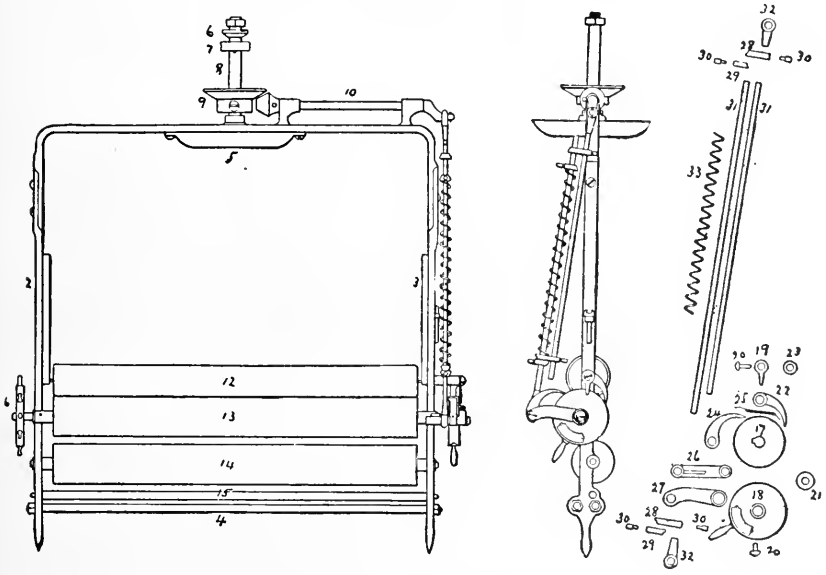
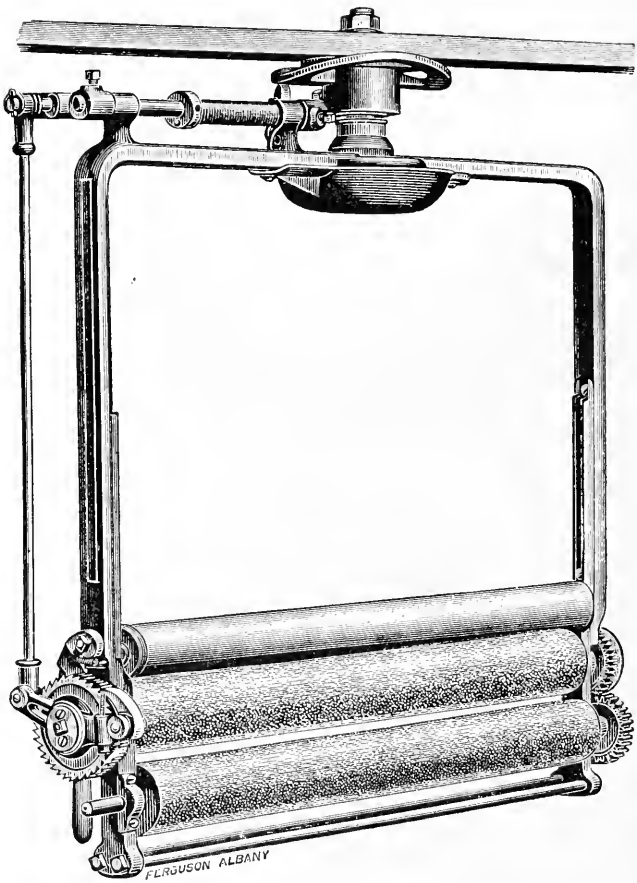


Fig. 18. Take-Up and Parts.

bottom of the frame. The spreader bow is supported and rotated by the vertical shaft. The weight of the take-up is supported by a hardened rounded steel collar (not shown in the cut) seated in a hardened steel cup, 5. This is sufficiently free to allow the take-up to move readily without leaving it too free to continue rotating after the stop motion has released the shipper. The bevel pinion 11, on top of the frame takes its motion from the standing gear 9, on the crosstree and by means of the crank 32, and spring connecting rod 33 and 31, reciprocates the dog 24, engaging the ratchet gear

17, on the end of the upper quartz covered roll 13. When the tension on the cloth is rightly adjusted the unnecessary take-up motion is absorbed by the spring and as the adjustment of this spring connecting rod device determines the degree of tension on



Take-Up, Outside Drive.

the cloth while being knitted, and is a most important factor in producing good cloth with a minimum of broken needles, detail drawing is given in this diagram.

The crank connection 32, is attached to the upper end of the connecting rod 31 ; on the other connecting rod 31, is a cylindrical

spring 32. These two rods are held together at either end by connecting links 28, securely fastened to one of the rods, but allowing the other rod to move freely through the other holes in the links

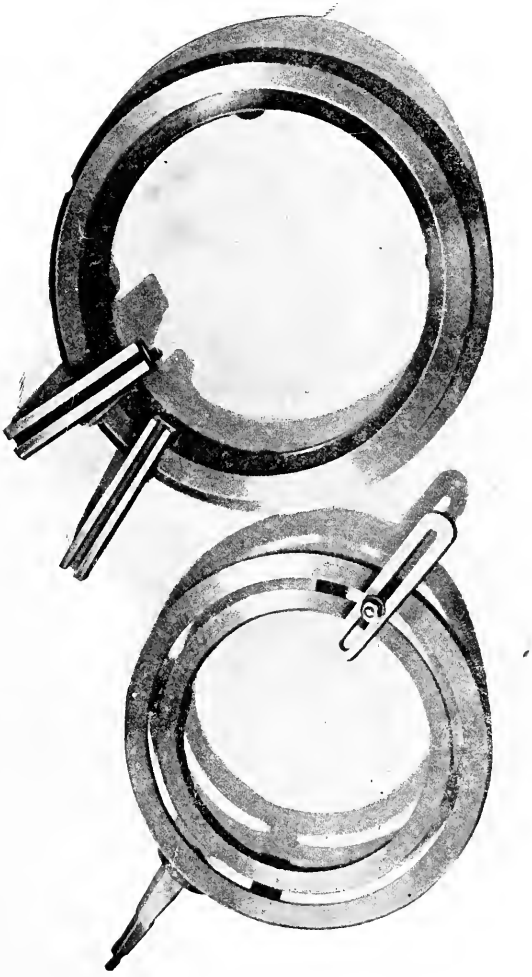


Fig. 19. Outside Circles.

when the crank actuated by bevel gear 11, on shaft 10, lifts the spring connecting rod mechanism. Spring 33, is so arranged between washer 29, fastened to the upper end of one of the rods 31, and link washer 28, fastened to the lower end of the other rod,

that it makes a compensating connecting rod. The lower end of one of the rods 31, is connected by means of part 32, and link 26, and 27, to a mechanism arranged to contain and operate pawl 24, on a ratchet wheel 17, which being secured to quartz covered roll 13, draws up or takes up the web of cloth as fast as it is knit. It is then rolled up on the incumbent wooden roller 12, which turns by virtue of its own weight on roller 13. The draft roller 13, is held in position by the short pawl 22, engaging with the ratchet wheel 17, on the end of the roller.

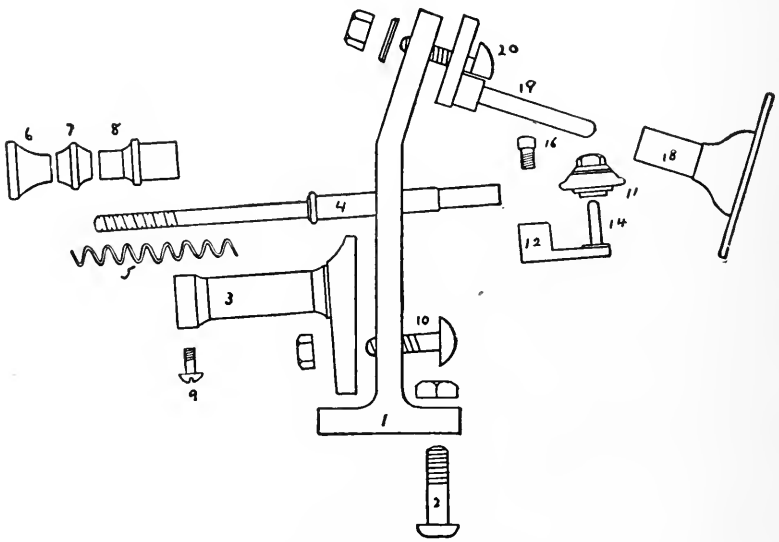


Fig. 20. Sinker Stand Parts.

When the tension on the cloth between the needles and the draft rollers will permit, the pawl 24, engages with ratchet wheel 17, causing the draft roll to move forward as far as is necessary to equalize the strain on the cloth. This tension is adjusted by means of spring 33. When the spring is at its full adjusted length the tension of the cloth is greater than the resisting force of the spring, but as more courses are knitted the tension of the cloth relaxes and the ratchet wheel yields to the pressure of the spring connecting rod turning the roll, taking up the slack cloth and maintaining the proper tension on the cloth between the needles

and the rolls. In the meantime it will be remembered that the unnecessary take-up motion is absorbed by the spring. As the web is taken up it winds on the wooden roll 12, and when the roll is sufficiently large the cloth is cut and the roll removed by lifting out of the parallel ways on the inside of the frame. When it is desired to unwind the cloth, both dogs may be thrown out of gear by pushing up the handle attached to the gear cover.

Outside Circles. Fig. 19 shows two kinds of outside circles and links. The smaller of the two is called the slotted circle. The

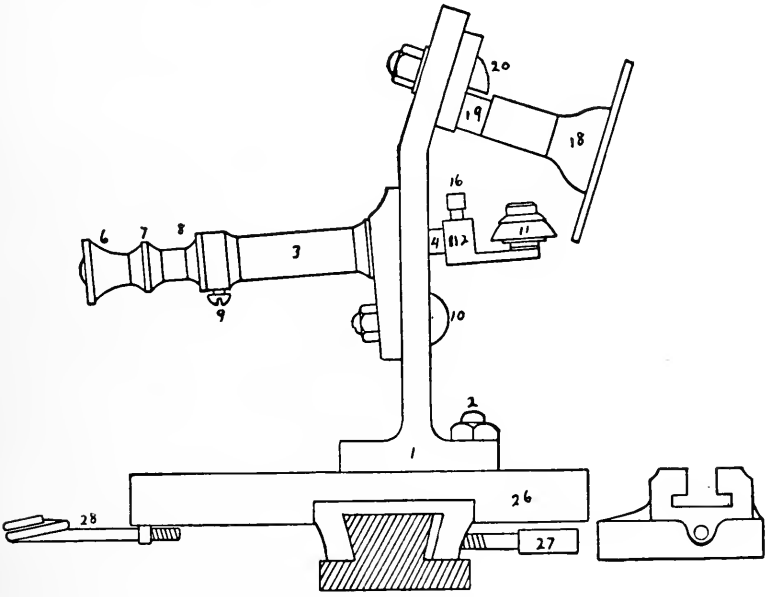


Fig. 20. Sinker Stand Assembled.

link on this circle is adjustable to almost any desired position. The larger one is called the dovetailed circle. A stand once set on this circle may be moved circumferentially without altering its adjustment. The links on this circle are always radial and cannot be moved in or out. The narrow link is generally used for plush work, the broader one for plain work. The circle is mounted on the projections rising from the bed plate, seen in Fig. 16, which brings it below the cylinder. The links bolted to this circle support the stands on which the outside burs and wheels run.

The Sinker Stand Fig 20, is a mechanical arrangement on the outside circle for supporting the sinker bur and the holding wheel. The sinker bur feeds the yarn up under the beards of the needles. The holding wheel is so arranged that it projects over and inside of the needles opposite the sinker bur and by means of the wide flange holds down the cloth to bring it in proper position and facilitate the action of the burs and needles so that new stitches may be formed.

The sinker stand 1, is secured to the links by the bolt 2. The tube 3, is secured to the stand 1, by means of bolt 10; tube 3, contains shaft 4, on which is spring 5. When the parts are assembled the spring 5, is confined between the shoulder on the shaft 4, and the collar 8, which is partially inserted in the tube 3, and secured thereto by set screw 9; the nut 6, is for locking nut 7, in its proper position. This arrangement is provided to give a yielding pressure to the shaft 4, which supports the bracket 12, with the stud 14, on which revolves the sinker bur 11. Bracket 12, is secured to the shaft 4, by screw 16. The shaft has a rotary adjustment, and is adjusted in and out by the nuts on the end of the shaft. When a bunch gets in under the bur, the shaft allows the bur to move back against the spring. After the bunch has passed the spring returns the bur to its position leaving the needles uninjured. At the top of the stand on the offset directly over the sinker bur, is supported the stud 19, which is secured to the stand with bolt 20, the holding down wheel 18, runs on stud 19.

The Presser Stand Fig. 21, supports the presser wheel, on the outside of the needles, which holds the beards of the needles down over the yarn while the lander bur (inside) raises the cloth and lands the stitches on the beards. The presser stand 1, is held in position on the link with bolt 2. The tube 3, is held in position on the stand with the screw 4. The shaft 5, is supported in tube 3, and the spring 6, is confined between the shoulder on the shaft and the end of tube, and is adjusted and set by means of lock nuts 7 and 8. At the inner end shaft 5, holds the presser wheel stud 13, with set screw 9. This stud is adjustable up and down and on it runs the presser wheel.

Inside Circles. Inside the cylinder and above it is the inside plate or ring, supported by four ribbed arms 1, Fig. 22, and secured

to the cylinder stationary stud by set screw 2. On the ring are the gripes 3, which support the inside bur arms. The ring is dovetailed and each gripe is clamped to it by set screw 4, on the inner end.

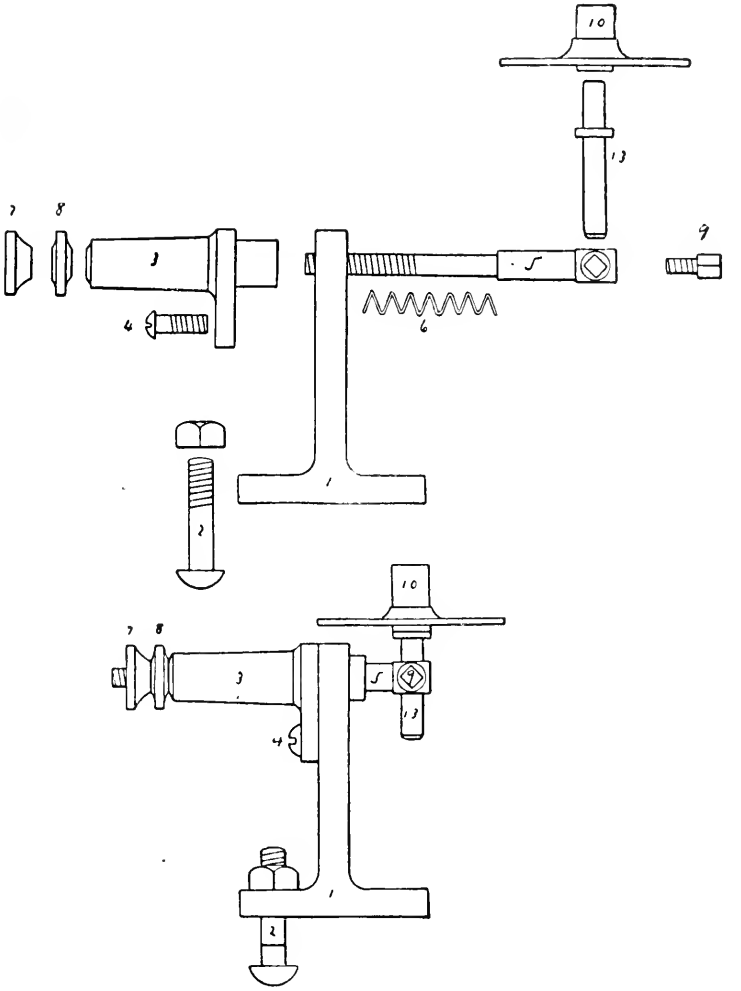


Fig. 21. Presser Stand Assembled and Parts.

When the screw is loosened the gripe may be moved circumferentially to any position without otherwise altering the position of the bur. The bur arm 11, may be rotated by loosening set screw

5 and allowing the holder 6, to be moved as desired. It can also be adjusted in and out with the use of set screw 10, and is capable of adjustment up and down by means of the right and left screw 9. On the end of bur arm 11, is the bur 12. When the web of cloth is on the machine the inside plate and inside burs are hidden from sight. The bottom stitches of the web are looped on the needles one loop to a needle.

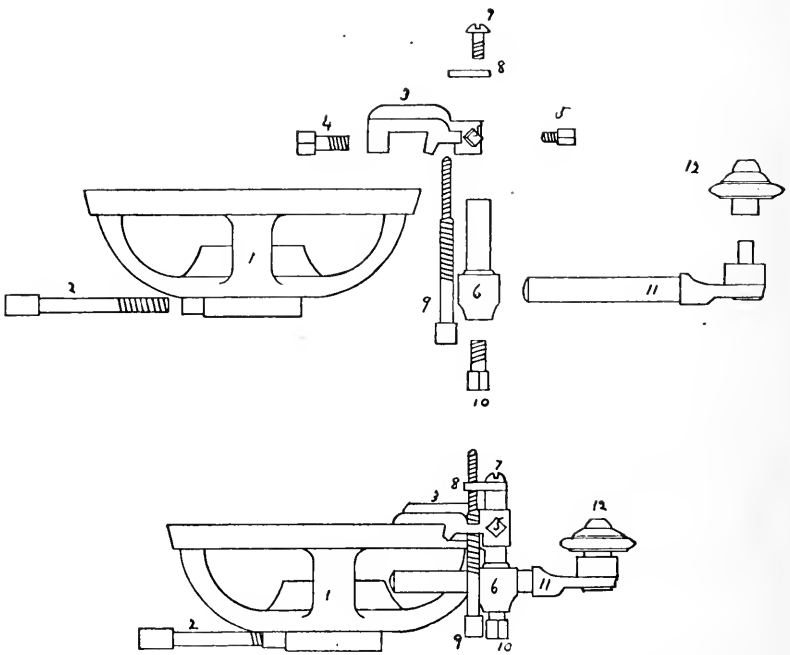
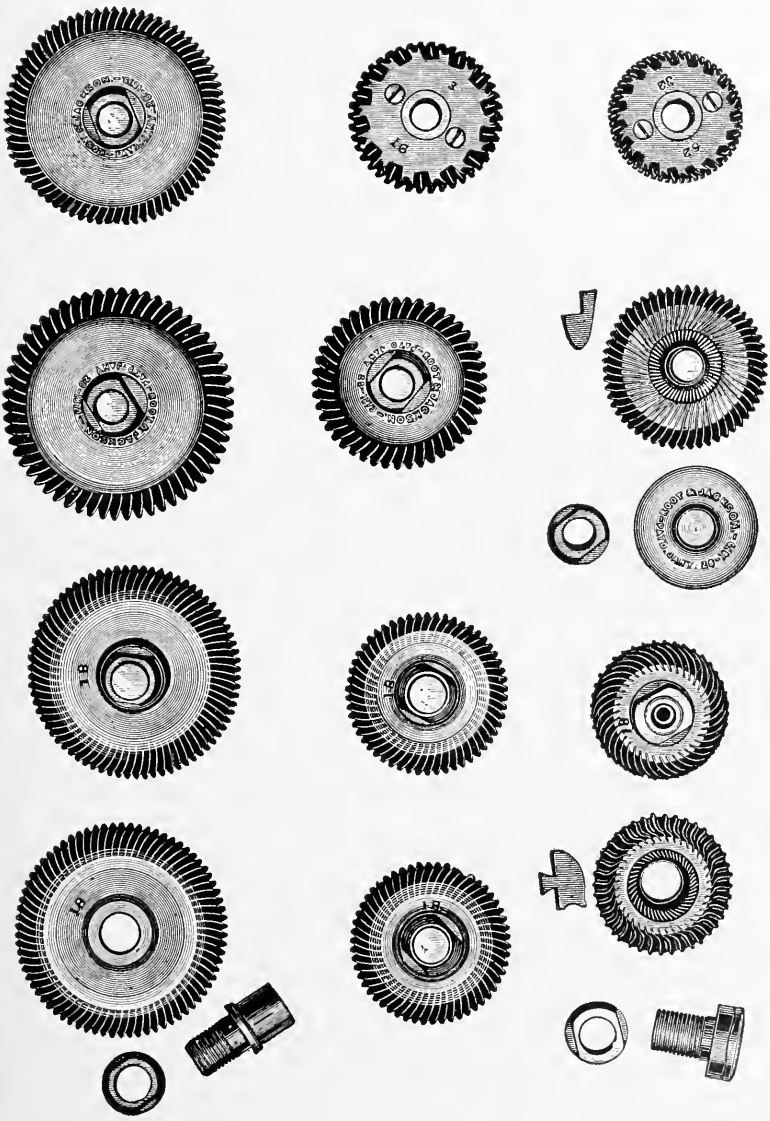


Fig. 22. Inside Circles Assembled and Parts.

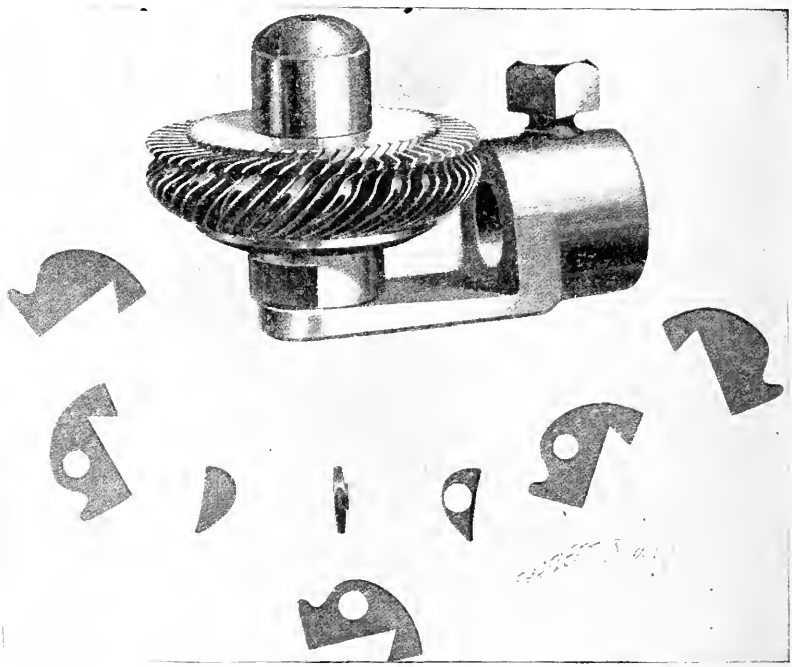
Burs. Burs are usually made with bronze bodies, though other metals and compositions are employed by different makers, or for that matter by the same makers. The blades are of steel; hardened and tempered in most instances, but often treated otherwise as the style of the bur seems to require, or the fancy of the maker or knitter dictates. The bushings are made of steel, are case-hardened and removable. The blades not only differ for the various functions they have to perform, but differ for the same



Burs and Parts.

employment according to the ideas of the designer, knitter or maker.

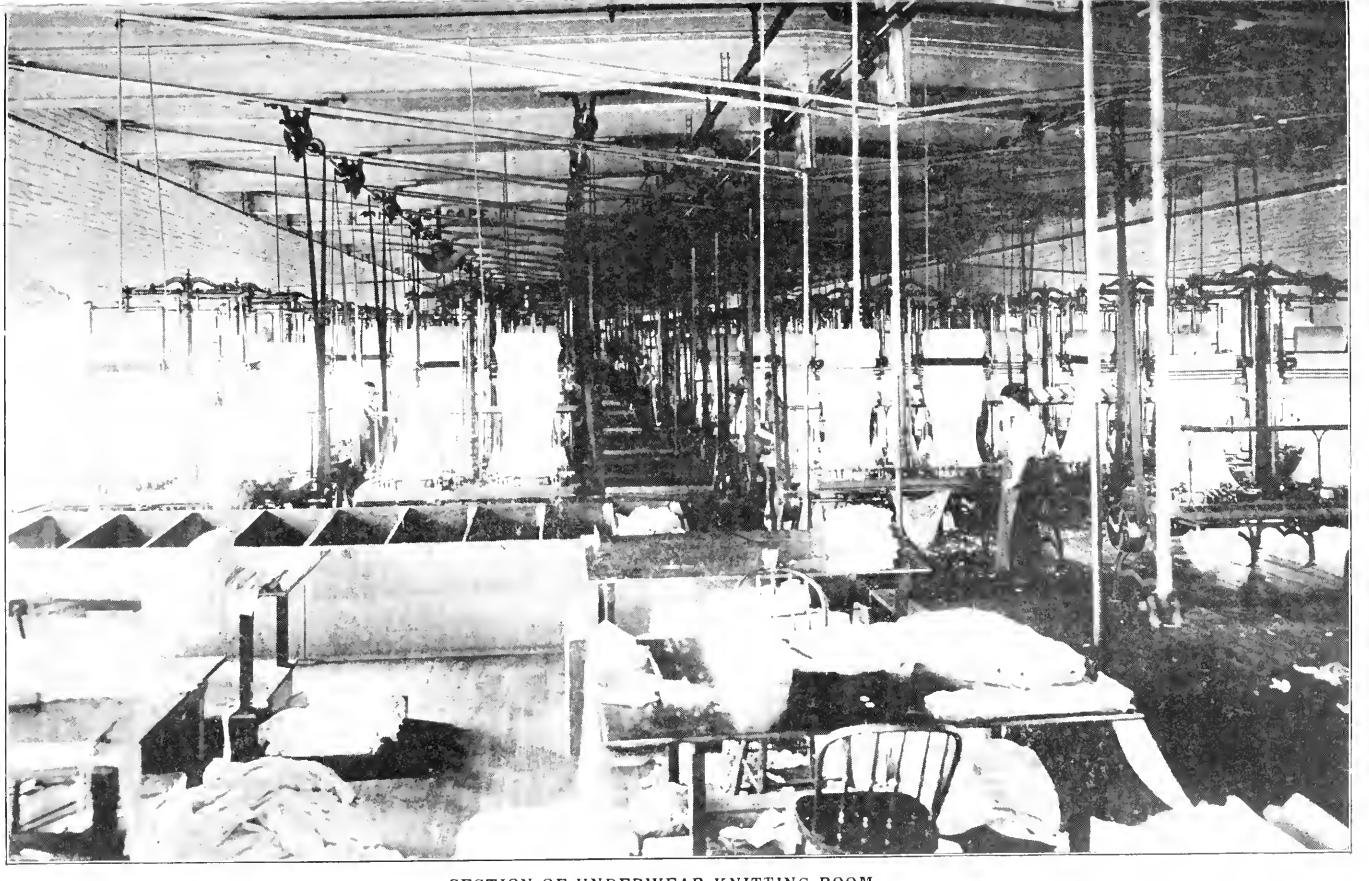
Inside Burs have either a self oiler, or the bur arms are provided with oilers that do not require replenishing for two or three days or more. This is very essential, for when the web is stretched from the needles to the take-up, the inside burs are only accessible in some machines after cutting the web, and difficult to get at in any machine. In some machines the cylinder is set high above the table to allow the knitter to reach up under inside to



Backing Bur.

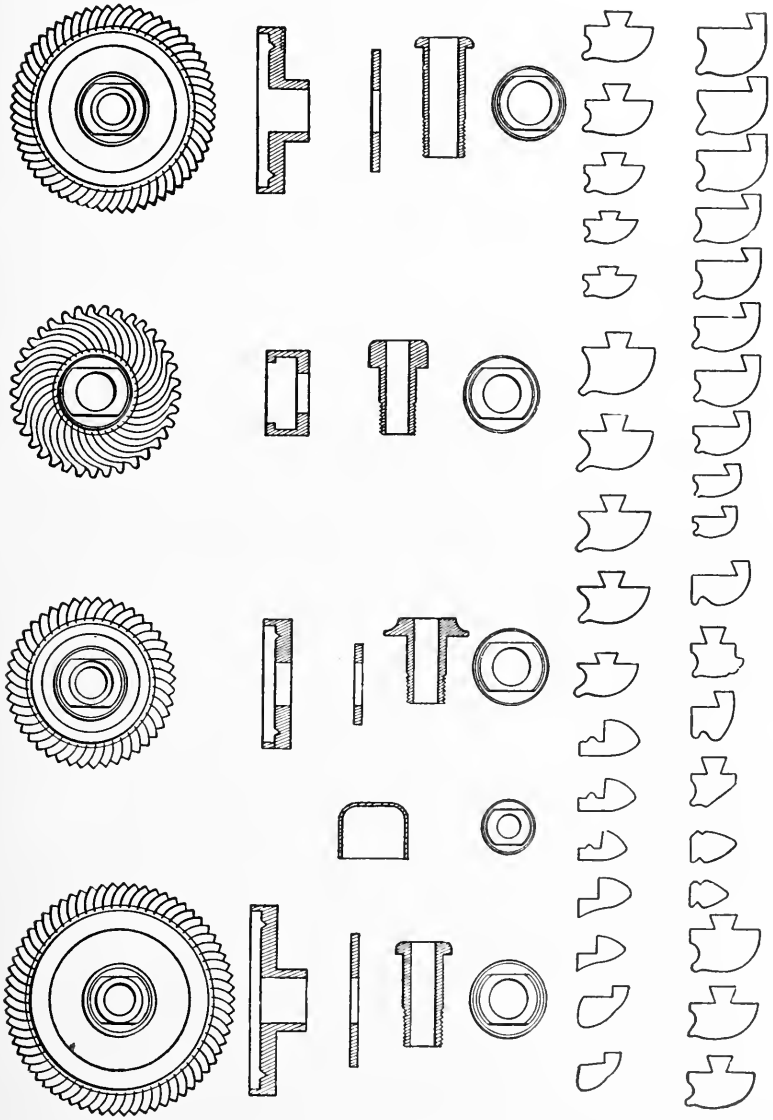
clean and adjust without cutting the web. In some machines the cylinder is close down to the table, but other advantages are gained by so doing.

The Feed Burs must correspond with the gauge of the needles, and in many cases permit of being changed to any desired gauge by removing the hub and putting in another of the gauge required. So, too in many cases can the blades be removed in case of wear



SECTION OF UNDERWEAR KNITTING ROOM

Lawrence Mfg. Company

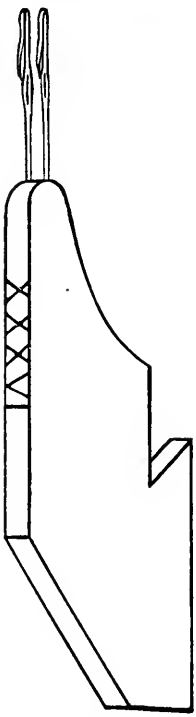


Burs and Bur Blades.

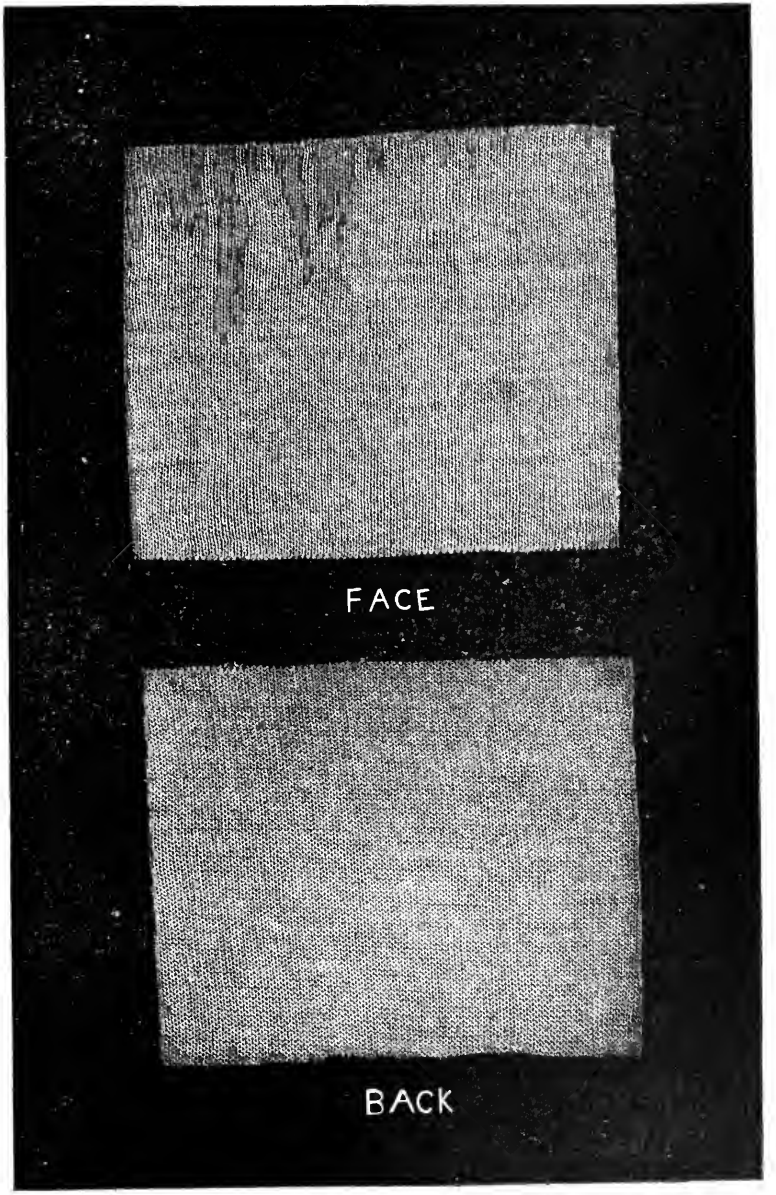
and replaced with new ones. In the landing and cast-off burs the wings can be replaced when necessary.

The burs push the yarn into and between the needles and in other ways manipulate it until it is cleared off the needles in a web. The blades strike the yarn quick and sharp blows and consequently are a considerable factor in determining the speed of running the machine.

The Backing Bur is for lacing among the needles a thread that appears mainly on the back of the web and is therefore called a backing yarn. This side of the cloth is napped to produce a pile or fleece fabric, or it may be left as it comes from the machine, as the fancy for a style suggests. Napping was done in former years on the knitting machine coincident with the knitting by severing the backing yarn and brushing out the loose ends to produce a pile or nap, but with the advent of the so called "fleece lined" underwear, napping machines were adapted to do that work, leaving the knitting machine to do its legitimate work. The usual way of lacing the yarn among the needles is to spring back alternate needles and lay the yarn in front of them and behind the others. This causes more severe strain on the needles than ordinary knitting. Another way of getting the yarn into the needles is to bend the yarn so that it may be placed alternately in front of and behind the needles. The style of bur to accomplish this object has a plate, to which in the press places, are hinged latches or sinkers which serve to hold back the yarn into the blade spaces in order to lay it in front of the needles. A stationary cam on the stand beneath the bur secures the opening of these latches to allow the yarn to enter the groove in the blades, and the contact of the needle pushes the latches and the yarn behind them into the spaces. On receding from the needles the latches open



One Lead, 36 Gauge, Actual Size.



36 Gauge Cloth (Spring Needle).

and release the yarn. This bur puts in a loose back and reduces the inward bend of the needles very considerably, though the friction slightly exceeds that of some other burs and slightly increases the side strain on the needles. A close study of the relations of the burs to the needles, and their action on the yarn will reveal

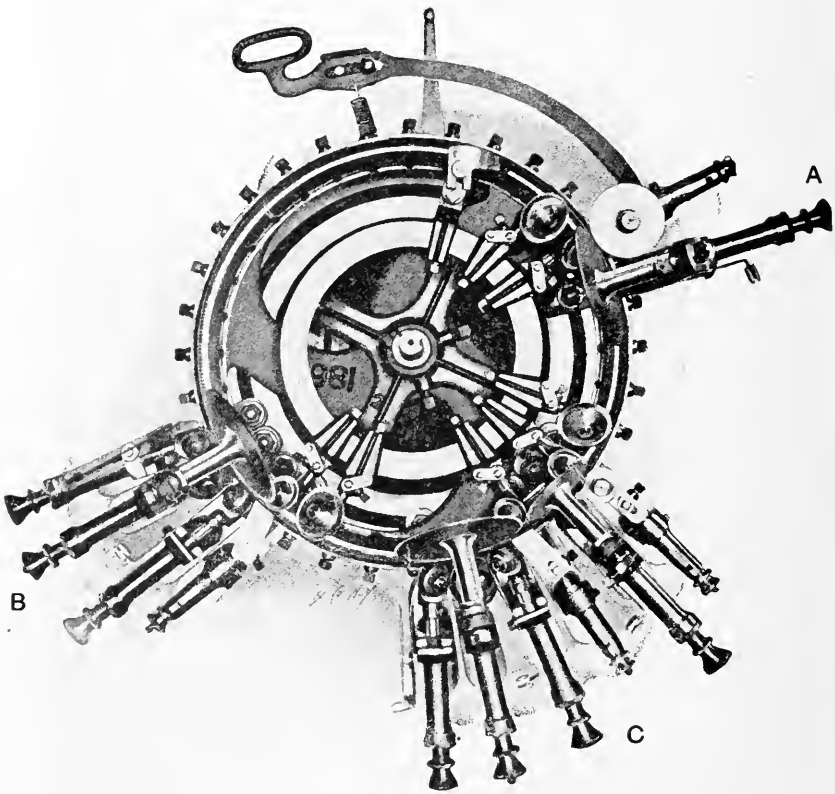


Fig. 23. Feeds.

much to the close observer and cannot fail to make the student a superior knitter.

Feeds. The large cylinder shown in the cut "Feeds" with the projecting collar screws is the needle cylinder. The direction in which this cylinder turns is counter-clockwise. Beside the cylinder and above it is the inside ring on which are the gripes. The center or vertical shaft is seen projecting up through the center.

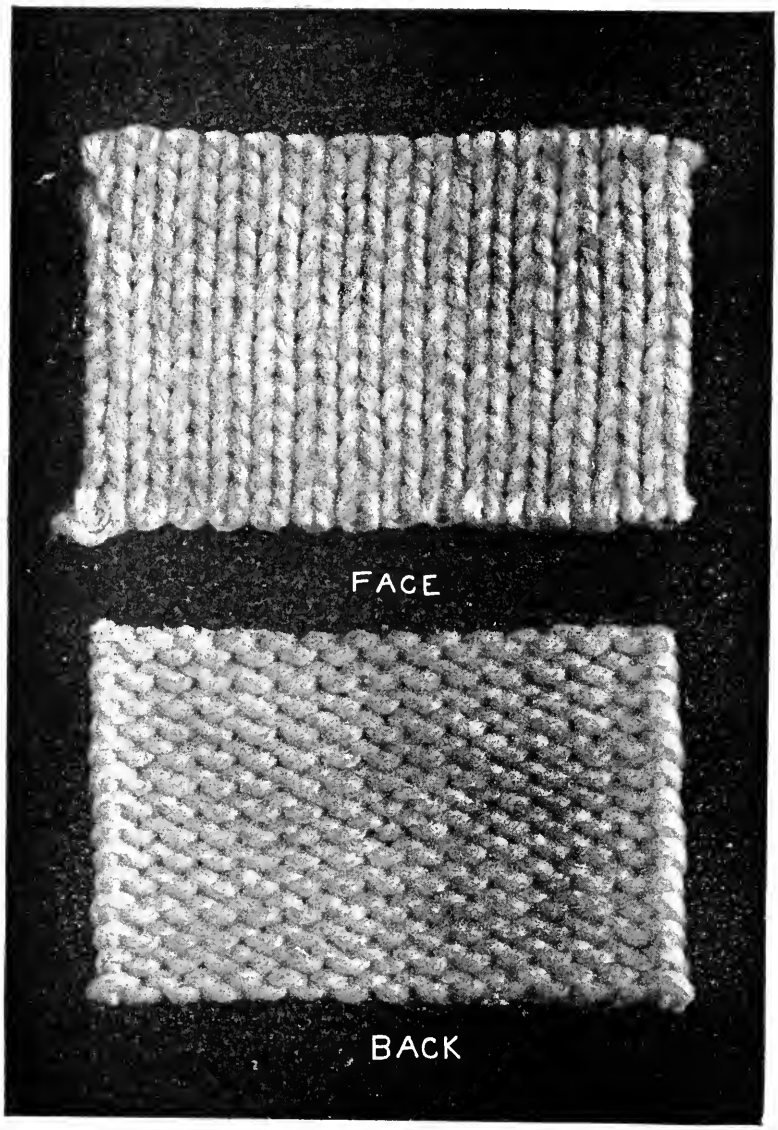
A Feed is a group of burs and wheels necessary to the formation of a complete stitch, whatever that stitch may be. Beginning at the right near the top of Fig. 23 and going counter-clockwise around the cylinder, the cut shows a plain feed A, a single plush feed B, and a double plush feed C. The plain feed makes the common knit stitch. Ordinary, or flat knitting is made with this feed. The plush feeds make what is called backing cloth; that is, a knit cloth with an extra thread looped into the back of the cloth. This thread when napped makes a fleece fabric. The face yarn is generally of cotton. The cloth is called single plush or double plush according as one or two face yarns are employed to make it. Almost anything that can be spun into yarn may be used for backing, such as goats hair, camels hair, etc. Plush cloth knit after such fashion is used for cloaks and overcoats, horse blankets, buffalo robes, etc., as well as underwear.

The Plain Feed, A, Fig. 23, a good illustration of which is shown on page 60, requires three burs, a holding-down wheel, and a presser wheel. The holding-down wheel is the largest of the group. Right under the hub of the holding-down wheel is the sinker bur; next comes the presser wheel on the outside of the needles and the lander bur on the inside of the needles; next the cast-off bur which raises the stitch off the needles. Sometimes when economy of space is desirable a single large inside bur is employed instead of two burs.

Knitting machines are usually furnished with four feeds to a cylinder, but more feeds may be employed except on small sized cylinders. The production of a machine is proportioned to the number of feeds.

Single Plush Feed. Single plush is plain knitting with a yarn looped in each course of plain stitches. As it is usually made it is looped in one stitch, then skips two stitches on the back, and is then looped in another stitch and so on, thus making this yarn appear on the back of the cloth almost entirely. The single plush feed is essentially the same as the plain feed, except that a backing bur and a clearing bur are employed in addition to the burs used in the plain feed. The backing bur cannot carry the yarn down far enough on the needles, so the clearing bur is employed to assist it, just as the cast-off bur assists the lander.

The feed, shown in Fig. 23 nearly opposite the plain feed, is



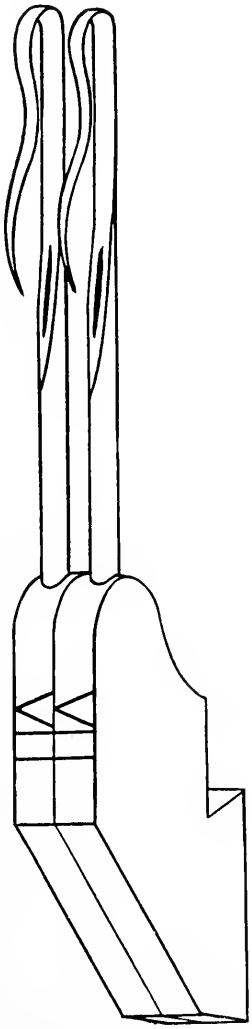
5-Gauge Sweater Cloth (Spring Needle) Composed of a Doubled 2 Ply French Spun Worsted.

a single plush feed B. Taking the burs and wheels in the order in which they properly come they are as follows:

1. Holding-down wheel.
2. Backing bur.
3. Clearing bur.
4. Sinker bur.
5. Presser.
6. Lander bur.
7. Cast-off bur.

As the holding-down wheel has to cover three burs instead of one — as in the plain feed — it should be larger than that required for a plain feed; on the other hand the large holding-down wheel will answer for a plain feed.

The backing bur and the clearing bur have to be held on to the stud by a nut, as shown in this cut, as the tendency of the work is to lift them off the stud. The backing yarn is fed into the bur by the guide shown. Sometimes the clearing bur is supported by a bracket secured to the backing stand. A flat presser is also shown, but either the large round presser shown in the plain feed or the small round presser shown in the double plush feed may be employed.



One Lead 7 Gauge
Actual Size.

A Double Plush Feed Fig. 23, C, may be made from a single plush feed by separating the single plush feed in the middle and inserting a sinker bur, presser and lander. It is then necessary to use another holding-down wheel on the original sinker stand; the added sinker puts in what is called the binding thread, and the presser and lander are to place it on the beards of the needles. As before stated the production of a machine is proportional to

the number of feeds thereon, but it is not good practice to crowd in as many feeds as the space around the cylinder will permit. In such cases the only space at which needles may be removed and replaced is at the stop motion, and a smash located at any other

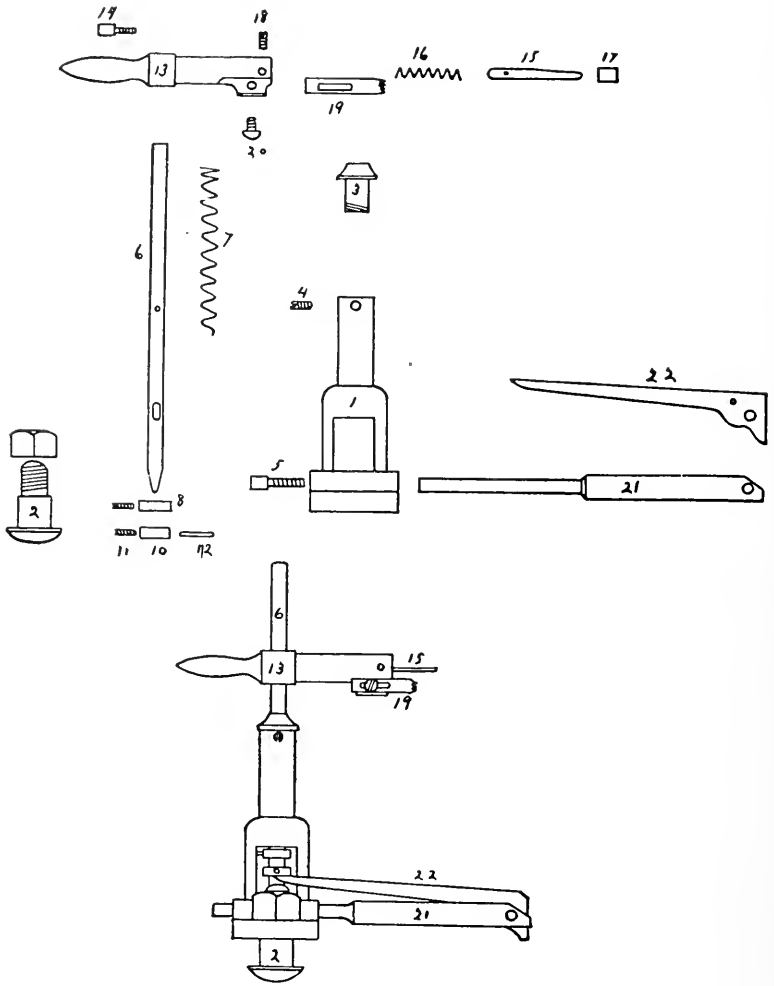


Fig. 24. Stop Motion Assembled and Parts.

place must be moved around to that point, thereby making a bad matter worse. Another objection against crowding in too many feeds to a cylinder is that more breaks, bunches, smashes, holes,

etc., appear in proportion to the increased number of feeds, causing an increased number of stops. Every stop lessens production. A certain number of stops will soon offset the increased production of one of the feeds, therefore, it is a matter of judgment of how many feeds may be profitably employed — stops, quality of yarn and fabric being considered.

The Stop Motion is an arrangement for automatically stopping the cylinder when a hole in the web appears or an accumulation of yarn occurs in the needles, and aids very materially in preventing a lot of bad cloth and a good many needle smashes. On a two-cylinder frame each cylinder is driven with a separate belt, to each of which is applied a shipper for convenience in starting and stopping each cylinder and its take-up, separately. When these holes in the cloth or bunches of yarn in the needles appear, the stop motion is so arranged that the shipper is made to act on the belt, shifting it from the tight to the loose pulley and quickly stopping the cylinder. The stop motion is supported on a link secured to the outside circle in a like manner as the stands. Fig. 24 shows detail sketches of parts, and an assembled cut of the Holt stop motion. Number 1 is the stand secured to the link screw bolt 2. In this stand is inserted the bearing 3, which also provides a shoulder; between it and a pin through the round hole shown in the spindle 6, is confined a spiral spring. The handle-bar 13, after being adjusted to its proper position, is secured to the spindle 6, with its set screw 14. At the end of the handle-bar is inserted the finger or feeler 15, made very sensitive by action of spring 16, inside of the handle-bar directly behind the feeler or telltale. Just beneath the feeler and attached to the handle-bar by screw 20, is the part 19. When the sensitive finger 15, finds a hole in the web, or the feeler 19, encounters a bunch of yarn or fly in the needles, spindle 6, is rotated enough to disengage the lever 22, which is supported at the end of the adjustable shaft 21. The action of the lever 22, releases the shipper which by action of a spring is forced back, and by its connections shifts the belt, thereby stopping the cylinder. When the trouble is remedied the telltales 15 and 19, are thrown into position again with the handle on 13. the lever 22 adjusted and the cylinder is again ready to start.

Speed. Such a variety of circumstances are attendant in the process of knitting a fabric that no hard and fast rule for speed can be devised. Though exceedingly short, some interval of time is required for the easy and perfect formation of the stitch on the needle. Wool, mixtures and other soft yarns cannot be knitted with the needles running at the highest rate of speed, because they are likely to break before the stitch is formed. On the other hand the hard twisted yarns for balbriggans may be knit at the highest speed because they are strong, and capable of sustaining the strain and the quick, sharp blows of the blades of the burs pushing, and at high speed fairly striking, the yarn between the needles in sharp bends. Before the yarn reaches the needles it lies straight across the bur spaces from one blade to another. The needle entering the space presses the yarn back between the blades drawing it over the entering blade until the full depth of the stitch is obtained, while all the time, the yarn meets with the resistance caused by the blades meshing into the needles behind it. This is what is termed *stress* on the yarn. The face yarns employed in making plush are generally very strong, and on them comes the principal stress; but so many burs and wheels are employed on this sort of work that a smash at high speed would prove altogether too serious to take the chances of the fast running that the strength of such yarn would permit.

Common practice is to run a 20-inch cylinder between 40 and 65 turns a minute. This corresponds to a needle speed of from 210 to 340 feet per minute. The following table of speed represents some customary speeds:

		Gauge.	Revolutions.
Twenty inch cylinder	Wool, Mixtures	18	45
	Plush	24	60
	Balbriggan	24	66

Greater speed than this can, however, be attained when all or most of the conditions are favorable thereto. The machines are geared so that the needle speed is approximately constant for all sizes of cylinders; that is, if the machine is belted properly for a 20-inch cylinder it will be right for all other sizes of cylinders. It is also geared so that for one turn of the receiving shaft a 20-

inch cylinder makes .254 turns. In other words, the machine is geared about 4 to 1. Four turns of the receiving shaft to about one turn of the needle cylinder. The receiving shaft should run about 240 turns, which will make the cylinder run about 60 turns. A table of the gearing of the Tompkins leaded needle machine is appended.

Diameter of Cylinder in Inches.	Diameter of Change Pulley in Inches.	Turns of Cylinder to one turn of Receiving Shaft.	Diameter of Cylinder in Inches.	Diameter of Change Pulley in Inches.	Turns of Cylinder to one of Receiving Shaft.
9	13/	.428	17	9/	.302
10	13	.414	18	9	.286
11	12/	.398	19	8/	.270
12	12	.382	20	8	.254
13	11/	.366	21	7/	.239
14	11	.350	22	7	.223
15	10/	.334	23	6/	.207
16	10	.323	24	6	.191

TABLES OF SIZES FOR FLAT GOODS.

	Size.	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
Men's Flat Shirts	Chest	...	...	...	...	...	...	...	...	...	34	36	38	40	42	43	46
	Length	...	...	...	...	...	...	...	...	...	29	30	31	82	33	24	35
	Sleeve	...	...	...	...	...	...	...	...	...	17	18	19	20	21	22	22
Men's Flat Drawers	Waist	...	...	...	...	...	...	28	30	32	34	36	38	40	42	44	..
	Inseam	...	...	...	...	...	...	27	28	29	29	29	30	30	30	31	..
	Body	...	..	...	...	...	...	13	14	15	15	15	16	16	16	17	..
Ladies' Flat Vests	Bust	...	...	...	...	...	...	...	30	32	34	36	38	40	..	..	..
	Length	...	...	...	...	...	...	...	30	31	32	33	34	35	..	..	..
	Sleeve	...	...	...	...	...	...	...	15	16	17	17	18	19	..	..	..
Boys' and Misses' Flat Vests	Width	16	18	20	22	24	26	28	30	32½	34	..	..	..	..	..	..
	Length	13	14½	16	18	20	22	24	26	27½	29	..	..	..	..	..	..
	Sleeve	7	8	9	10½	12	13	13¾	14½	15	17	..	..	..	..	..	..
Boys' Flat Drawers	Waist	...	...	...	..	24	26	28	30	32	..	..	..	..	..	..	..
	Inseam	...	...	...	...	18	21	24	25½	28	..	..	..	..	..	..	..
	Rise	...	...	...	...	10	11½	11¾	12	14	..	..	..	..	..	..	..
	Back	...	...	...	...	11½	12½	13	14	15½	..	..	..	..	..	..	..
Boys' and Misses' Flat Pantalets	Waist	16	18	20	22	24	26	23	...	...	..	..	..	..	..	..	..
	Body Length	8½	9	10	11	12	13	13	...	...	..	..	..	..	..	..	..
	Inseam	9	10½	12½	14	16	17	18	...	...	..	..	..	..	..	..	..

TABLES FOR SELECTING CHILDREN'S UNDERWEAR, ACCORDING TO AGE.

SHIRTS.

Age.	Size.
6 months to 1 year requires	16
1 year to 1½ years "	18
1½ years to 2 years "	20
2 " 4 " "	22
4 " 6 " "	24
6 " 8 " "	26
8 " 10 " "	28
10 " 12 " "	30
12 " 13 " "	32
31 " 14 " "	34

The cylinders are selected according to the sizes of the garments to be made. The following table is for spring woolen underwear weighing about six pounds to the dozen garments:

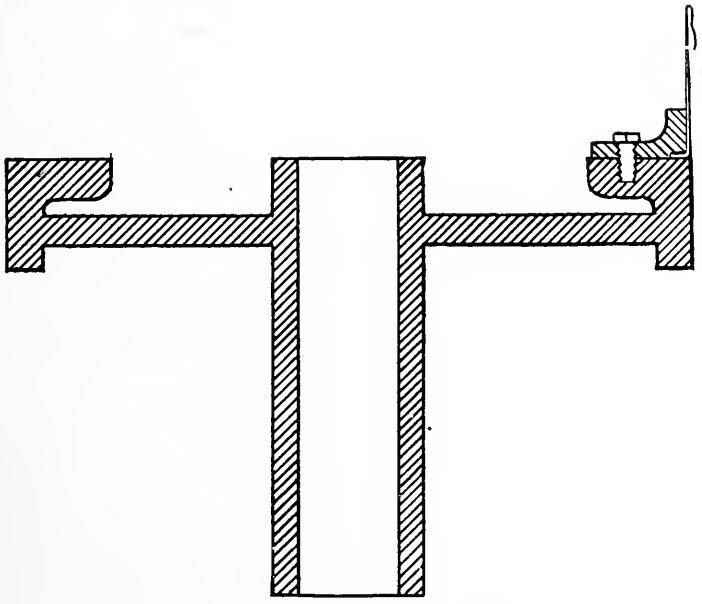
Size of Garment.	Size of Cylinder.	
	For Shirts.	For Drawers.
30		16
32		16
34	16	16
36	17	17
38	18	17
40	18	18
42	19	18
44	19	18
46	20	19
48	20	19

STARTING UP AND ADJUSTING.

Setting Trick Needles. Remove the needle plates. See that the tricks, both vertical and horizontal, are free from corrosion or dirt which would keep the needles from going into place; or from oil, which would work up onto the needle and streak the cloth. Place the needles in position, replacing the needle plates as each plate space is filled. Take care to place the plates so that the needle nearest each end of the plate is securely held. When all the needles are in position adjust a stiff wire pointer from the inside plate or heart to the needle line and plyer the needles so that they stand horizontally, and so that all just touch the end of the pointer when the cylinder is revolved.

Setting Leaded Needles. Remove the needle plates and see that the verge (the part where the leads bear) is free from corrosion, gum and oil. Lay the leaded needles out alongside on a board in rows, having the beards uppermost. Put one plate in position but leave the screw loose. Pick up as many leaded needles as the plate will cover, place them between the verge and the plate, rather low down, and then press gently on the cap. They should rise easily into line. Screw the cap down gently and then square the end leads with a small square placed on the ledge of the cylinder (the part which supports the plate). Tighten the screws enough to keep the leads from tipping. Replace the next

plate; place the needles as before, pressing them against the preceding lot so that no spaces are left between the leads. Square the exposed end of this lot of needles. Repeat this around the cylinder. The last plate cannot be squared but the first lot will keep them from tipping. If a space is left, it may be necessary, in order to fill it, to cast a lead with one needle and file the superfluous lead away. If the space is less than half a lead, loosen all the plates slightly and begin tightening on the side opposite,



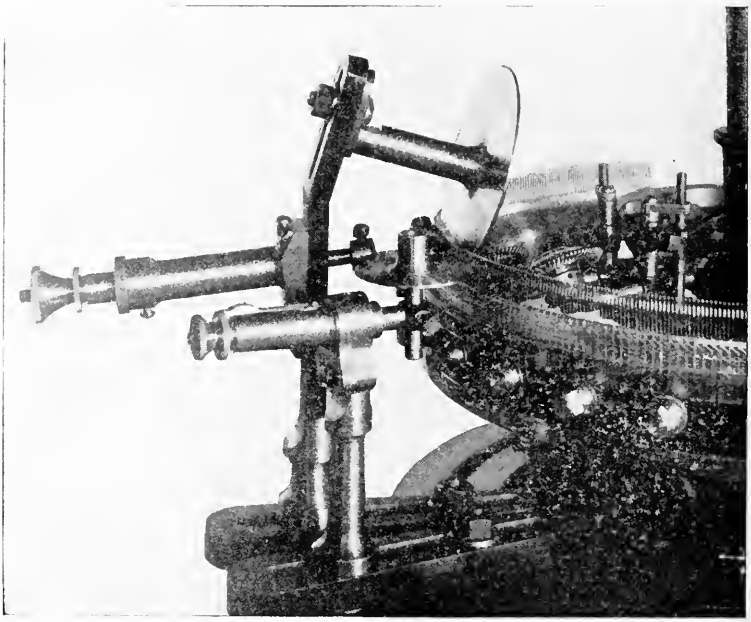
Method of Setting Trick Needle.

tapping them gently and approaching the space from both sides. This should close the space. Very little plyering should be necessary.

Bur and Wheel Adjustment. The functions of the burs and accessories in forming the stitch should be thoroughly understood before attempting to set the machine. Briefly, they are these: As the needles revolve, the cloth wheel or cam presses the old stitches (looped onto the needles to start with) down to the lowest exposed portion of the needle, and holds them there while the sinker bur runs the yarn up under the beards of the needles and while the presser which follows the sinker closes the beards

at the presser, the cloth wheel or cam releases the old stitches gradually, allowing the lander to land them on the points of the beards. The cast-off follows the lander and casts the old stitches clear of the needles.

Setting the Burs. Divide the needle line into as many parts as there are to be feeds — four is the conventional number



Plain Feed, and Inside Cylinder.

— leaving room on the front of the machine for the stop motion. These divisions may be marked by setting the cast-offs, provisionally, placing the first one just before the stop motion; i.e., so that the needles when in motion reach the cast-off before they do the stop motion. When the needle line has thus been divided, finish the setting of the first cast-off. The wings should reach from below the beards of the needles, but not to the base, up a little above the heads of the needles, and should run with no back lash. If the bur has back lash (is loose) tip it forward, thus binding it slightly. The ideal position is that in which the bur is

tight enough to cast off the stitch evenly without interfering with the needles, and yet not so tight as to put unnecessary stress on the needles, thus working them in the leads or tricks. Occasional slugs in the yarn must be taken into account in this consideration, as slugs are more difficult to cast off than the ordinary yarn. The bur should come far enough through the needles to even the new stitches in the heads of the needles as the old stitches are cast off, yet not so far as to put undue stress on the stitches, thus breaking them and making holes.

Lander. The lander is set just ahead of the cast-off. The blades should reach as low as possible without striking the cylinder or leads, and should carry up far enough to land the stitches a little above the points of the beards. It should be loose enough in the needles to run without working the needles, but not so loose that the entering blade will strike the approaching needle, thus cutting the yarn or bending the needle. It is good practice to leave enough space between the lander and cast-off to permit taking the cast-off from the stud in order to clean or repair it.

Cloth Wheel. The cloth wheel or cam is set just ahead of the lander so that the old stitches will be held down until the lander raises them. It should carry the old stitches down to the base of the needle, but without putting undue strain either on the cloth or on the needles at the front edge of the wheel or cam.

Sinker. The sinker bur is set in the needle space covered by the cloth wheel, far enough from the front of the wheel to make sure that the old stitches will be carried down before the sinker is reached and far enough from the back edge of the cloth wheel to leave room between the sinker and the lander for the presser. The sinker should be set with the upper part of the entering blade inclined toward the head of the approaching needle; that is to say, if the needles are moving from left to right, the bur should be tipped from right to left, and vice-versa. The extent to which the bur should be tipped is dependent on the following considerations: In the first place the sinker blade is generally a deep blade, and but little tip is possible without interfering with the needles, which, of course, should be avoided.

Again, the yarn is looped under the beards by the blades of the sinker and in this process the blades have to crowd the yarn

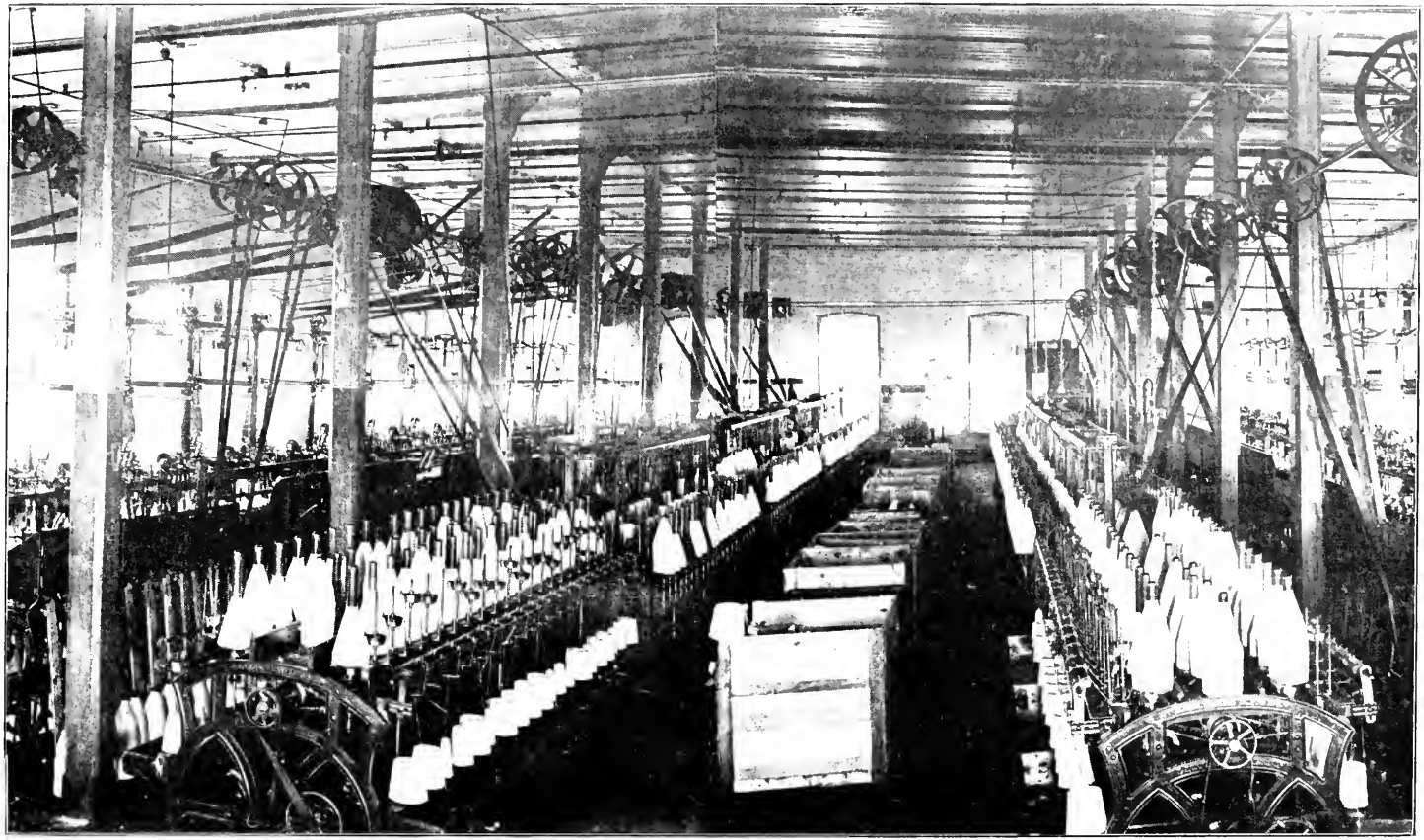
between the needles, and a considerable amount of force is required to do this. The force is supplied by the needles to the bur and in doing so the needles bend a little, allowing the bur blades to fall slightly behind their normal position and making interference likely from this cause. Now, the position of the bur to be sought is that in which the yarn will be surely placed under the beards, looped to the required depth, and carried well up in the heads of the needles, with the least stress on the yarn and on the needles and without interference with the needles. If the bur is tipped too much, it works the needles excessively and is likely to cut the yarn. If not tipped sufficiently, it interferes with the needles and picks off the beards.

Presser. The presser should be set to hold the beards closed as the stitches are being raised over them. This space is just a little ahead of the center of the lander. Space must be left between the presser and the lander blades to allow the rising stitches free passage, otherwise, they will be cut. When hard twisted or wiry yarn is used the flat presser is frequently used and is made long enough to cover all the beards between the sinker and the lander, thus keeping the yarn from dropping out of the needles until caught by the old stitches.

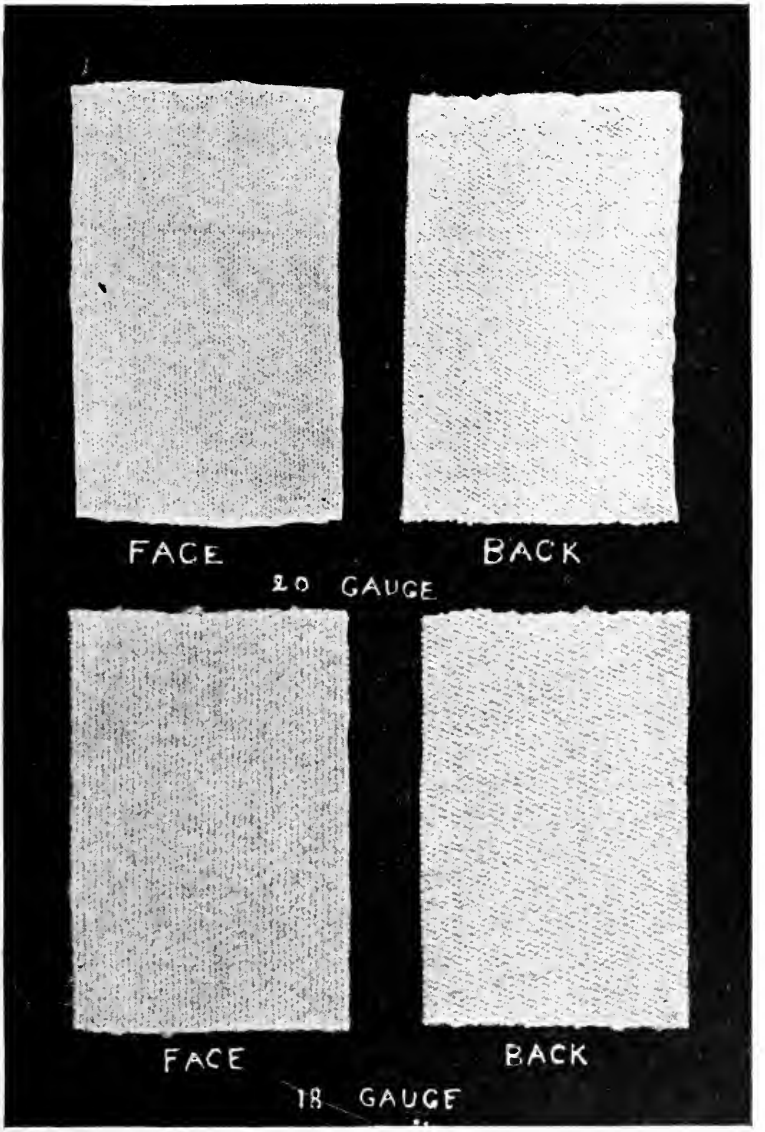
This completes the setting of one plain feed. The other feeds are set in the same manner. Before starting the machine all bearings should be lubricated and oil cups filled.

Starting Up. To start the machine take a tube of knit fabric, preferably of about the width of the fabric to be made, and of the same or finer gauge, pass it over the take-up rollers so that it will be rolled up when the take-up is in action, throw out the ratchet so that the fabric may be drawn down, and draw it down over the spreaders so that by stretching it a little it will reach the needles. Then throw in the ratchets in order that the fabric will not descend further. Select the needle space that is freest from obstructions, generally the stop motion space, and press the fabric near its edge down over the needles until the beards catch and hold it from coming off. Begin putting the fabric on near a sinker bur and continue in the direction opposite to the direction of rotation.

Threading. When the available needle space is filled, take



VIEW IN ONE OF THE KNITTING ROOMS OF THE AKEN KNITTING COMPANY, SHOWING KNITTING FRAMES MAKING 20- AND 22-GAUGE FLEECE LINED CLOTH

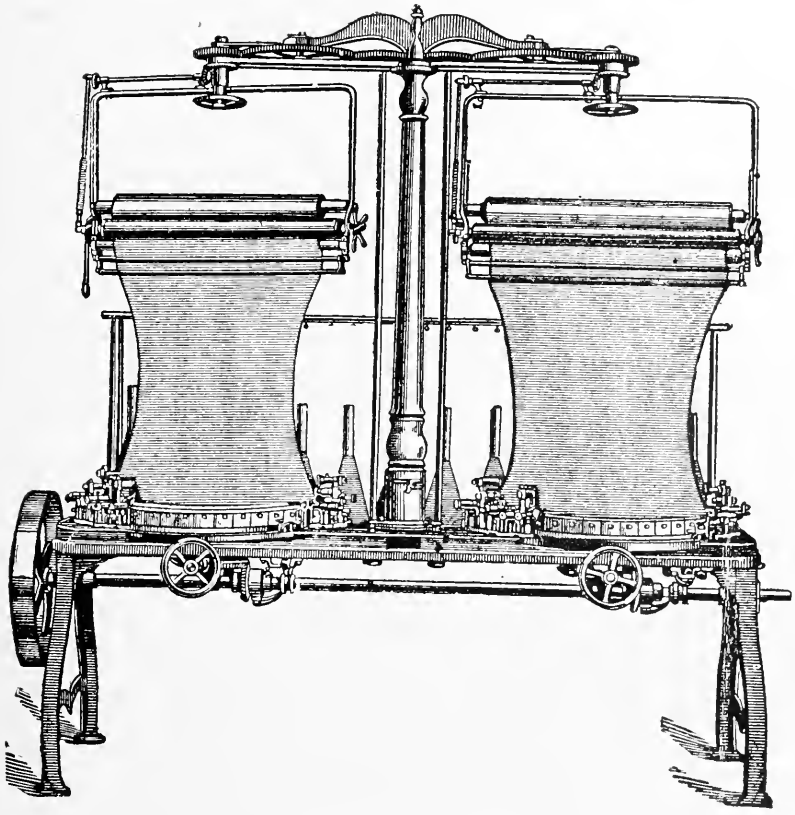


Merino Fabric.

a bobbin of the yarn to be used, place it on its rack directly under the screw eye nearest the sinker stand, pass the yarn up through this eye, then through the outer end of the guide and finally through the inner end. The yarn should be delivered as near to the bur as possible, and a little above the nibs. This necessitates placing the inner end of the guide close to the bur and the needles, but care should be taken that it is not so close that a slight pull on the yarn or a bunch on the needles will pull the guide against the bur, causing it to drag and break needles. After threading the guide, draw the sinker bur back, pass the end of the yarn around it, and let the bur come back into its position. If the edge of the fabric is ragged it should be trimmed with shears, otherwise the sinker will pick up these ragged edges and break needles. In any case, the machine should be turned gradually to avoid pick-ups. Turn until more exposed needles are available, and continue putting on the fabric. If the first feed is properly set, the old fabric will be clear of the needles after leaving the cast-off, but will be held to them by a new loop on each needle. When these new stitches approach the new sinker, thread it as with the first, and so on around.

Evils to Look for and Remedy. When the fabric is on all the needles, turn the cylinder once or twice by hand and then examine the new stitches. It will generally be found that in some cases one stitch straddles two needles, making a drop stitch effect. Hold down the fabric at this place, press down the beard of one of the needles and let the stitch off of that one. At the next bur the stitch will form properly. If the sinkers are not set deep enough the stitches will be too tight and will break. If the pressers are not pressing enough the needles will load up, that is to say, two or more stitches will be left on the needle. This will occur even when the pressers are deep enough, if some of the needles are bent inward. If the cast-off is too high it will break the stitch in casting off. If it is too low, it will not even the stitch in casting off and the fabric will not look well. Remedy all these defects and see that everything is running free and the take-up is working properly, before putting on the power; and in putting on the power, let it be for half a turn at a time, and keep ear and eye alert for trouble. A bent needle or a bent blade, a rough

bearing, a misplaced guide, a bobbin kicked out of place — any one of many little things may let the fabric off the needles or break a lot of needles if caution is not used in starting. If half a turn with power discloses no trouble, try a whole turn or more, feeling the fabric frequently to make sure that it is being taken up properly. If the tension is too severe it will finally pull the fabric right off the needles, and if it is not enough, the push-downs

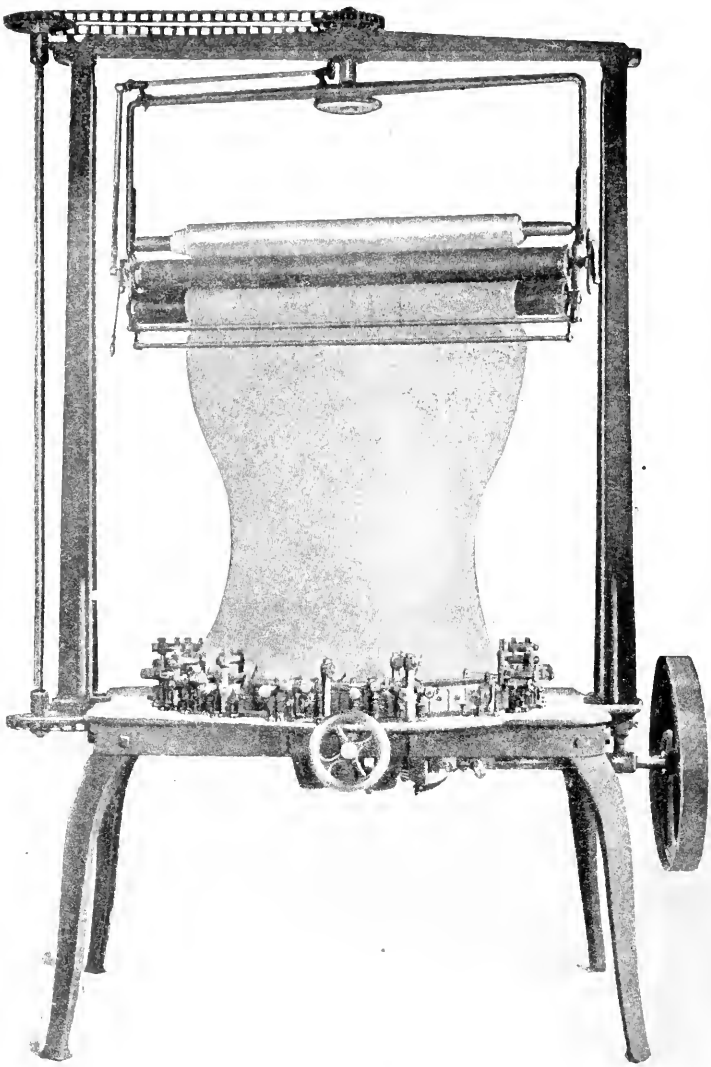


Trick Needle Frame.

cannot keep it clear of the sinkers and a smash will result.

After running up a little fabric, stop the cylinder and look for defects. A high beard will make a long stitch, or a tuck. A bent needle will make a line. Needles out of line will make a vertical streak of tight or loose stitches according as the displace-

ment is inward or outward. A short needle will make a line. Plyer or remove defective needles.



Trick Needle Stockinette Frame, Chain Take-Up Drive.

Evening the Stitch. The stitch should be evened by marking each yarn one foot from the guide, turning the cylinder

slowly, noting which marks reach the guide first, and shortening the corresponding stitches or lengthening the others according to the weight of fabric desired. Continue this until all the yarn feeds alike.

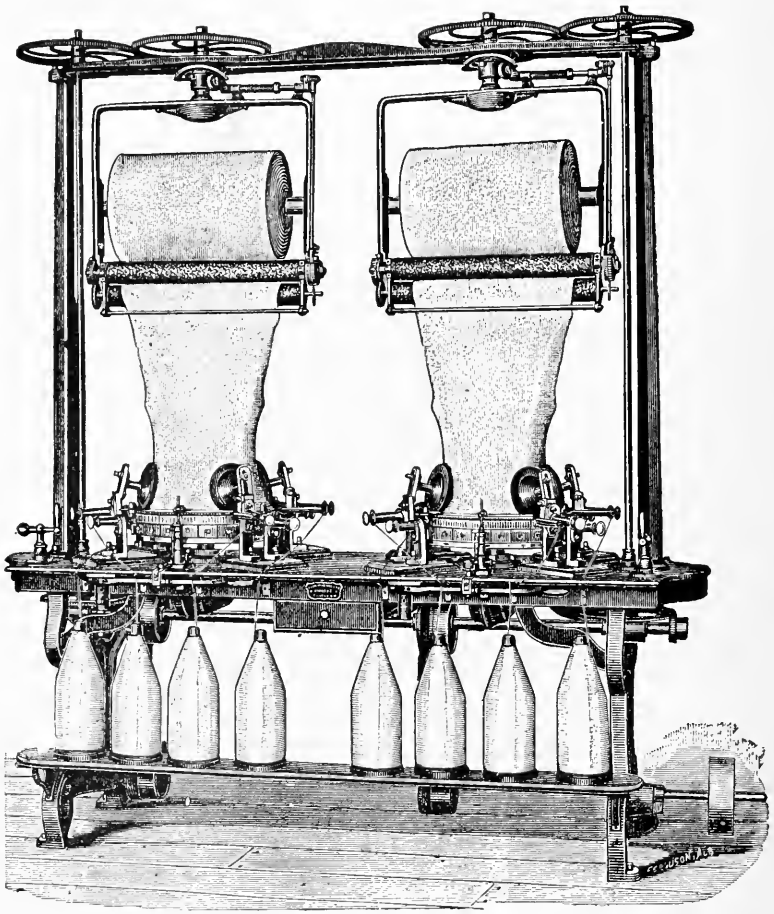
Adjusting the Stop Motion. Before letting the machine run without watching, the stop motion should be adjusted so that the feeler will enter a hole and stop the machine. Some stop motions have a waste claw. This should be adjusted near to the needles to catch bunches or thread that stay on the outside of the needles. The stop motion spring should be adjusted as lightly as possible without making it stop the cylinder unnecessarily. If the spring is set hard it will enlarge the holes and sometimes bend the needles at the same time.

Plating. Plated work has one kind of yarn on the face (the inside when on the machine) and another kind of yarn on the back. It may be made by using a guide with two sets of holes to accommodate two different yarns, the face yarn being the upper one as delivered to the bur. Of course when two threads are used each should be equivalent to about half the weight of the single thread used for fabric of the same weight and gauge.

A better way of plating is to use two sinker burs to each feed and deliver the face thread to the first sinker in order of rotation, making the stitch of this bur longer than that of the following one. The difference in stitch depends on circumstances, but from 1″ to the foot to $1\frac{1}{2}$″ to the foot is usual. Plated work with two burs has some marked advantages over single thread work. A nice appearing garment may be made with expensive stock in the face and cheap stock on the back. The sinker burs divide the work between them and make an evener stitch and are less likely to overreach than when one bur puts in the yarn. The fabric is generally stronger, having two threads; it is durable and it runs well, and if a yarn breaks the fabric does not leave the needles as in single thread work.

Cut Presser Work. Designing for the knitting machine is analagous to designing for the loom. It is obvious from the foregoing that if four feeds and four different colored yarns are used, the fabric will be striped horizontally in a pattern containing the four different colors, and this pattern will repeat itself at every

revolution of the cylinder. By increasing the number of feeds, the width of the pattern and the number of colors may be increased. From this and from the construction of the machine it is evident that changes in the yarn effect the fabric horizontally or across its



Another Type of Leaded Spring Needle Machine. Overhead Take-Up Drive. Stands Fastened to Bed of Table.

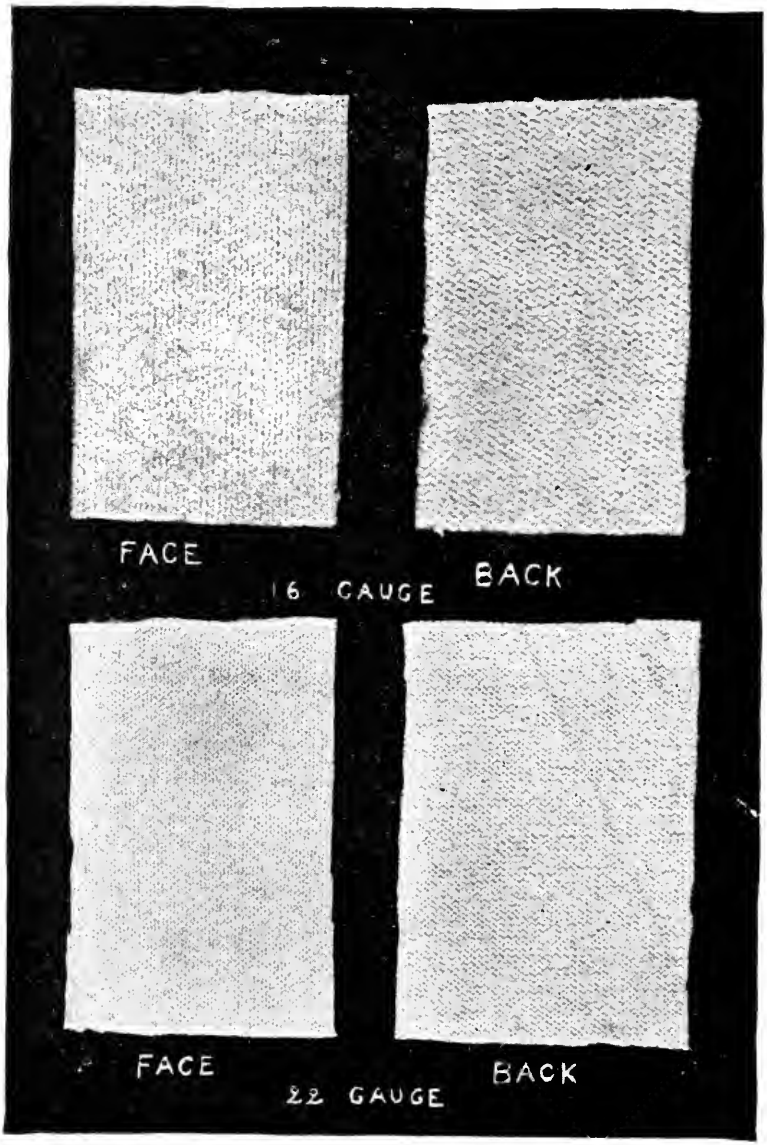
length, and that vertical or lengthwise effects must be caused on individual needles, for the fabric rises vertically from the needles.

Now, suppose that the cylinder is set up with but one feed, this feed having a round presser, and suppose the presser has been

nicked on a milling machine so that the nicks correspond to the needles and so that each succeeding needle comes to each succeeding nick. The result will be plain fabric just as if the presser were not nicked, but the presser will make a certain number of revolutions to each revolution of the cylinder. Suppose that the cylinder has 600 needles and the presser has 100 nicks; then the presser will revolve 6 times to one revolution of the cylinder. Now suppose one nick is filed deeper than the others so that the needle which enters it is not pressed. Then every hundreth needle will not be pressed, and at every turn of the cylinder a tuck stitch will be left on each of these six needles. If this were allowed to continue each of these six needles would load up and break, for a new stitch would be placed under the beard at every turn, and not being pressed off, would be retained there. The tuck stitch is desired in order to get a vertical effect in the cloth. Possibly one tuck is required, or two or three, as the case may be, but it is not desirable to injure the needle, so at intervals this must be pressed off. It may be done in two ways, either by adding another feed with a plain presser, or by removing or adding a needle. Suppose that another feed with a plain presser is added. Then every hundredth needle will have a tuck stitch as it passes the cut presser and all the needles will be pressed at the next feed. The result will be a fabric in which every hundredth stitch in every other course is tucked. These tuck stitches will occur in a vertical line at every hundredth needle. The width of this pattern is 100 and its height is 2.

The pattern is {	Press 99	Skip 1	Cut Presser. }
	Press	100	Plain Presser. }

If the plain feed is removed and the original cut presser feed is used, this will load up every sixth needle. If one needle, however, is removed, then at every turn of the cylinder the skip-cut will step one needle ahead, that is to say, one needle farther around the cylinder in the direction of rotation. The needles that were skipped at one revolution will be pressed the next revolution and the tuck stitches will take a diagonal course of approximately 45°, inclined to the left, upward, as the fabric is viewed on a machine that turns from left to right (anti-clockwise). If one needle had been added instead of removed, the diagonal would have been



Merino Fabric, Slightly Brushed.

inclined to the right, as the presser would then step back at each revolution of the cylinder. At every hundredth revolution the skip space would be back to the needle where it started.

A similar result would be obtained by leaving the needles as at first, 600, and making one more nick in the presser, or taking one out. The effect of this would be to step forward or back one needle at every hundredth needle, one needle at the first hundred, two needles at the next, etc.

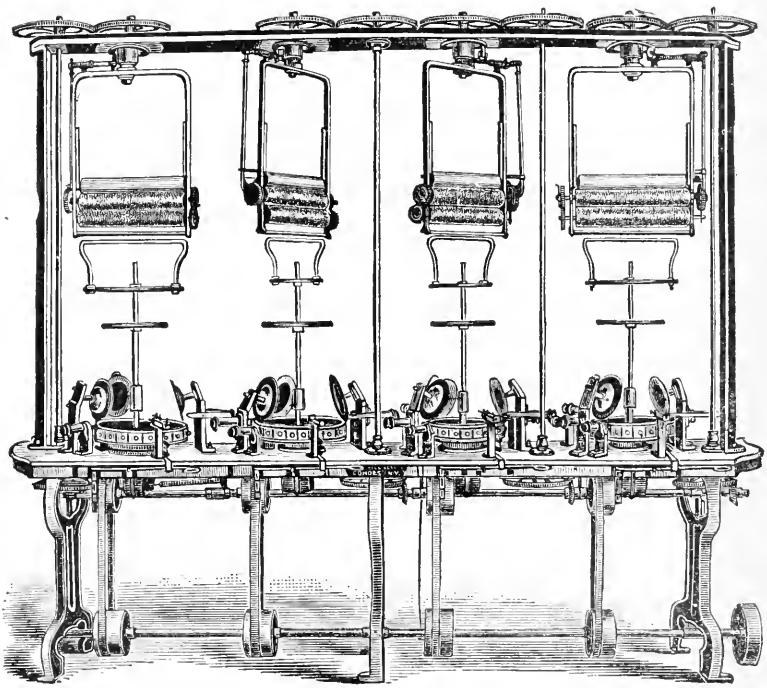
The above are the fundamental principles of tuck presser work. It is customary to run a plain presser after each cut presser for the ordinary forms of work, but of course, any combination may be used. To show how the pressers should be cut for any desired pattern, take a piece of cross-section paper having as many vertical spaces as there are needles in the pattern and as many horizontal spaces as there are courses. Number the horizontal rows of spaces to correspond to the pressers. For instance, if there are four pressers, number the horizontal rows, 1, 2, 3, 4, and then repeat 1, 2, 3, 4, to the end of the allotted space. Then mark the squares to be tucked. When all are marked the pattern for any one presser may be read on the lines numbered to correspond to it, that is to say, read for No. 1 presser the first No. 1 line; then the next, and so on stringing them together. If pressers 2 and 4 are plain their pattern will be press-all.

Collarette. When a considerable amount of plain work is required between the tuck work, as for collarette, an automatic device is used to substitute plain pressers for cut pressers without stopping the cylinder. A popular collarette combination is three tuck pressers in unison (3 tucks on the same needles) followed by two plain pressers. The pattern is generally "press one, skip one."

Backing Cloth. Backing cloth, including single plush and double plush is plain knit fabric with a thread or yarn caught in the stitches but not forming stitches itself. Backing cloth may be made with a sewing needle by taking the common or "flat" fabric, and running a heavy basting thread across it, making the courses close together. It this basting thread were then napped into a fleece, the fabric would be "fleece lined," and it would be single or double plush according as the original fabric was single

thread or two thread. The word single or double applies to the face and not to the backing. If the backing thread were a material that would kink and curl after knitting, the material would be astrachan, or bouclé cloth.

On the knitting machine the backing is put into the fabric by lacing it among the needles before the face thread or threads, if two are used, are looped under the beards. The backing is not placed under the beards and does not go there. Suppose the ma-

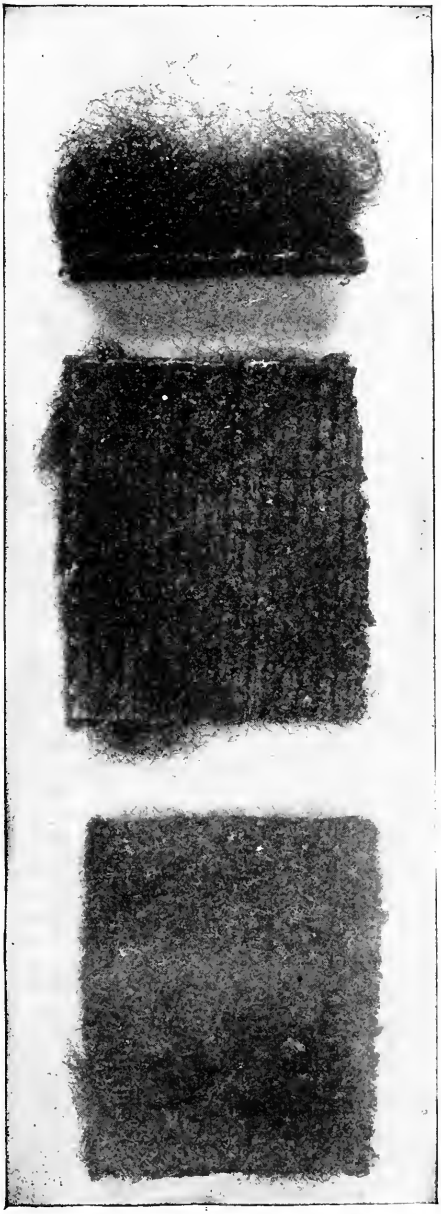


Four Cylinder Sleever.

chine is set up for flat work and with only one feed, for simplicity. Also, suppose that the one feed has been running and making cloth. Now suppose that a comparatively heavy but loose spun yarn is taken, and beginning just ahead of the sinker, where the fabric is held down, is laced in front of one needle and in back of the next two and so on, working from the sinker bar. Suppose that this yarn is pressed down to the base of the needles, so that

the sinker will not pick it up, and that the cylinder is slowly turned in order to get more needle space in which to lace the backing. If this is done the flat fabric will be transformed to single plush.

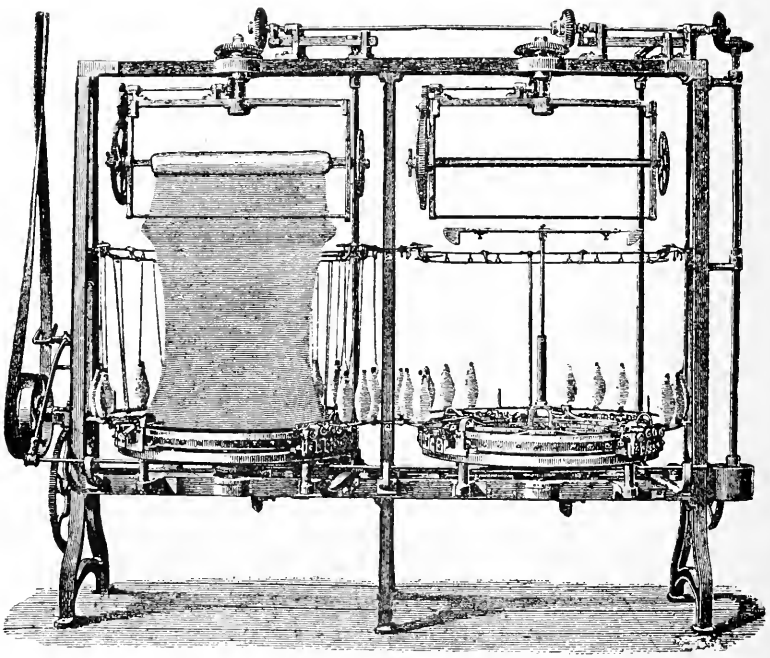
It will be noticed that the three requisites to make the changes were space in which to lace the backing on the needles (for the fabric must be held down before the backing can be placed in) means of lacing the backing thread, and means to carry the backing thread down clear of the sinker. To get the space the push-down must be long enough or of sufficient diameter to give the space, and the sinker and presser should be set pretty well back in respect to the push-down. To lace the backing in the needles a bur similar in shape to a sinker is used, but larger and with a deeper nib and the reverse angle. This bur is blocked so the needle will be pushed



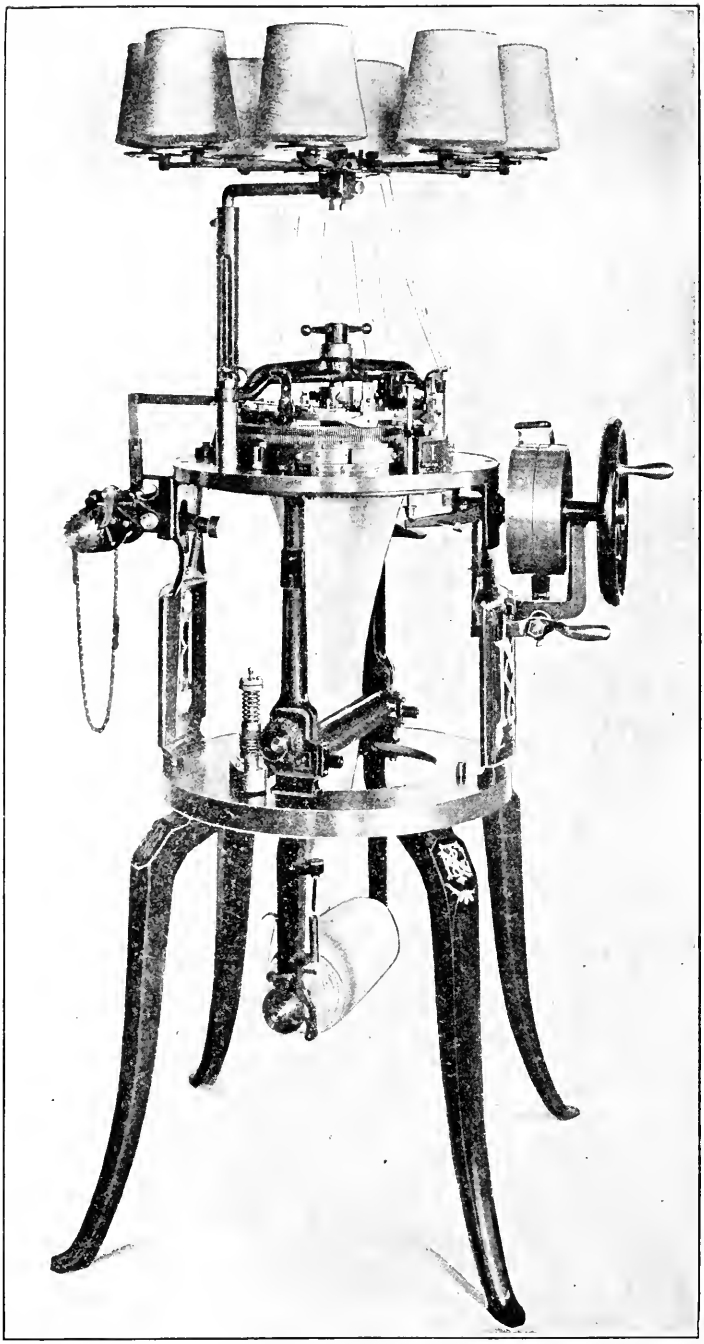
Cloth: Wool Backing, Buffalo Robe.

back at intervals and the backing will be placed in front of the needle so pushed back and back of the other needles. This bur will not carry the backing down far enough to clear the sinker, so a clearing-bur is put between the backing-bur and the sinker. The clearing-bur is like the cast off, only being on the outside of the cylinder it works downward instead of upward. A combination of this kind — a backing and clearing-bur preceding a plain feed — makes a single plush feed. Of course, as many such feeds may be used as the cylinder space will allow.

To make a double plush feed, remove the cast-off from the single plush feed, and bring another complete flat feed up close to the single plush feed. With this arrangement the backing thread is brought up to the heads of the needles between the two feeds and is held there by the first face thread which is called the binder, because it binds the backing. In double plush the backing does not show on the face as in single plush.



Type of English Frame.



LATCH NEEDLE RIB KNITTING MACHINE WITH REVOLVING CYLINDER AND AUTOMATIC CHANGE FROM PLAIN TO TUCKED STITCHES

Nye & Tredick Company

KNITTING.

PART II.

LATCH NEEDLE KNITTING.

Latch-Needle Knitting has been exploited to a much greater extent than has Spring-Needle Knitting. It enters into the manufacture of almost every line of knitted goods, is a leader in the stocking industry, and nearly, if not quite so, in the underwear mills.

Since the time of Walter Aiken, latch needles have been used in various positions to make fabrics of a great variety of stitches; and in different systems, as the Lamb, Heginbotham, and Leighton. Since the invention of the dial plate for supporting a series of needles, horizontal to and in conjunction with the vertical needles in the cylinder, latch-needle circular frames have been utilized to a great extent in the production of all kinds of knitted wearing apparel, outer as well as under garments. For knitting fabrics for underwear, or more specifically shirts and drawers, latch-needle machines may be classified as *Flat* or *Straight*, and *Circular*.

LATCH NEEDLE CIRCULAR MACHINES.

The circular machines may be divided into three classes.

1. **The Revolving Needle Cylinder** in which the needle cylinder, needle dial, take-up, and fabric revolve (or strictly speaking, rotate); the cam ring, cam dial plate, and bobbin rack remaining stationary.

2. **The Stationary Needle Cylinder** in which the cam ring (to which are fixed the vertical needle actuating cams), cam dial plate (to which are fixed the cams for actuating the horizontal or radial needles), bobbin rack, and cross bar revolve; the needle cylinder, needle dial, take-up, and fabric remaining stationary.

3. **The Flat Head Circular Machine** in which the needle plate or dial is located *outside* of the needle cylinder.

Each type of machine may be subdivided into *Plain* and *Automatic*.

Fig. 25. Fabric for Shaped Goods. Knit on Automatic Machines.

The *Plain Machines* produce but one class of fabric, a straight, tubular web of either a plain or a tuck stitch, the fabric being used in making what are known as straight goods.

The *Automatic Machines* make a tubular web of either a plain or a tuck stitch, or a combination of both; in the latter, the stitch is changed automatically from one to the other. The fabric made with the combination stitch is used in making shaped goods. (See Fig. 25.) In these knitting machines the needles of the horizontal needle dial are controlled by movable needle-directing cams operated automatically. These cams move the needles farther out, or draw them in, as required to obtain the characteristic stitches for the plain or tuck fabric for the shaped garment.

In making shaped goods, the 1 and 1 stitch (Fig. 26), is usually employed, viz.: All the needles in both cylinder and dial. For making straight goods, it is common practice to use the 2 and 2 stitch (Fig. 27) with every third needle out of both cylinder and dial. This, the Swiss double-ribbed stitch, produces what is known as the *Richelieu* fabric. Various other combinations of stitches may be made, as 2 and 1, 3 and 1, 6 and 2, 4 and 4, etc., and also fancy tuck lace stitches, making fabrics of various effects for a variety of styles.

Machines up to 10 inches in diameter are commonly used for making children's goods. For fleece-lined underwear, sizes may be employed up to 10 inches for children's, 11, 12, and 13 inches for ladies' shaped goods, and 14, 15, 16 and 17 inches for men's (straight) goods.

Measurement of Knitting Machines. Fig. 28. The old method of measuring is from back to back of the needles, but this system often occasions misunderstandings; as each different gauge needle gives a different needle diameter. Diametrical needle measurement may mean any one of three things; from the outside of the hook of the needle on one side to the outside of the hook of the needle on the other side; from the center of the needle on one side to the center of the needle on the other side; and from inside of the needle on one side to inside of the needle on the other.

Cam-surface measurement has been adopted by many knitting machine builders. This measurement is taken from the outside diameter of the cam surface of the needle cylinder and not from the needles; that is to say, the cylinder for a 10-inch machine will measure

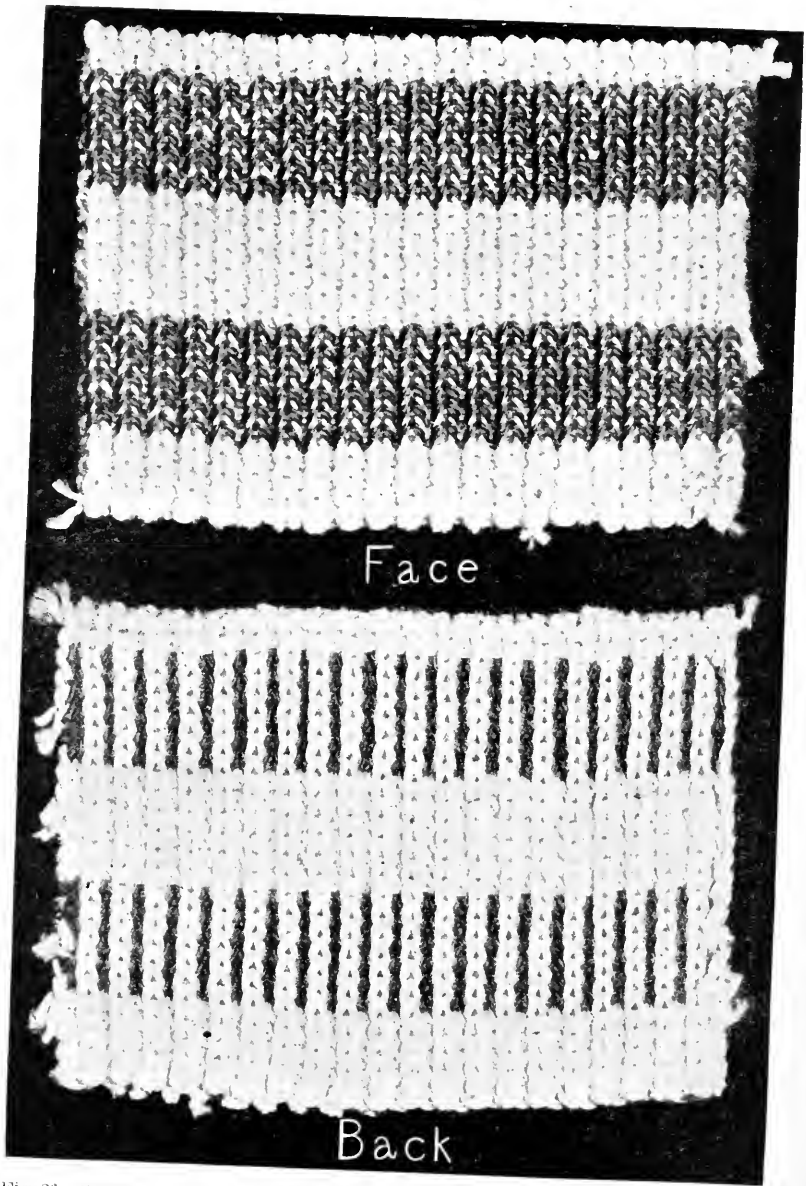


Fig. 26. One-and-One Plain Stitch. Fabric slightly stretched. All the Needles in both Cylinder and Dial.

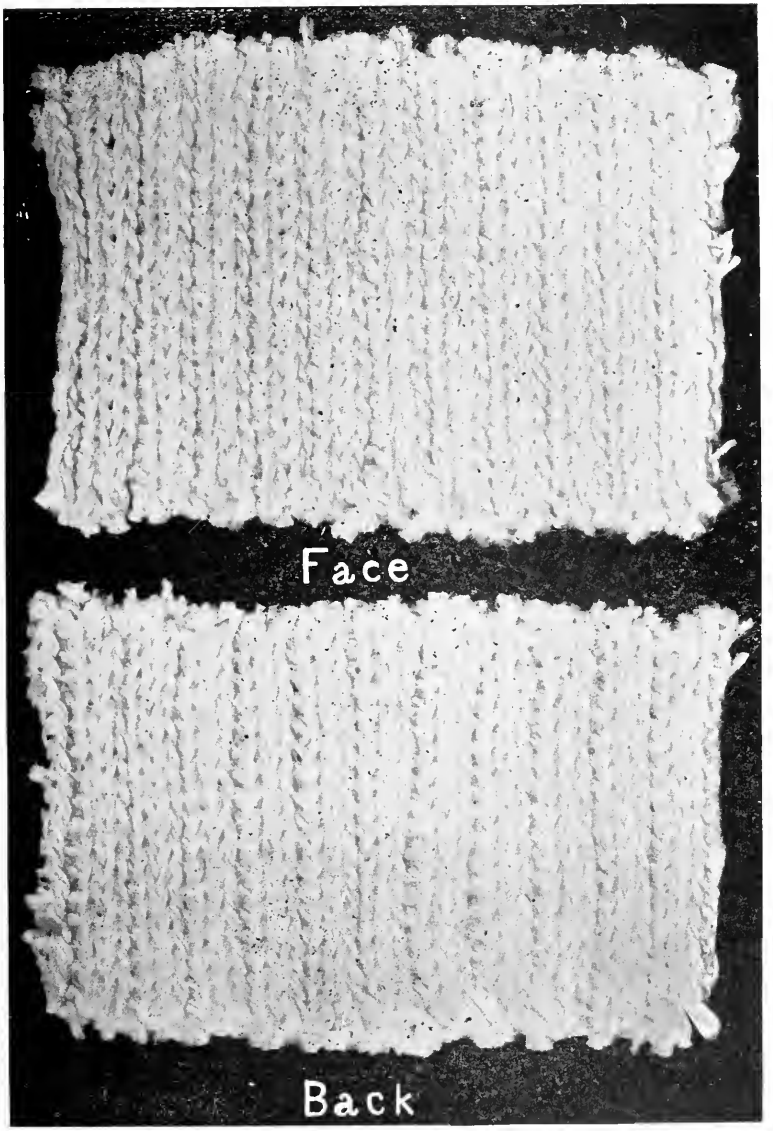


Fig. 27. Two-and-Two Stitch. Every Third Needle out of both Cylinder and Dial.

10 inches at its greatest or outside diameter. In most cases, the cam-surface measurement will give a reading one-quarter inch larger than the old system, thus, a 4¼-inch machine (modern method) would correspond to a 4-inch machine by the old measurement.

Rib Knitting is done on a machine having two sets of needles, one forming the back of the fabric, the other forming the face. When the two sets of needles form, and cast off completed loops at every feed on the machine, the fabric is called a *plain rib*, each needle showing a distinct longitudinal wale or rib, both on the inside and on the outside of the fabric.

The *formation of the stitch* in rib-knitted goods differs from that of flat goods in its principle, the effect being produced by revers-

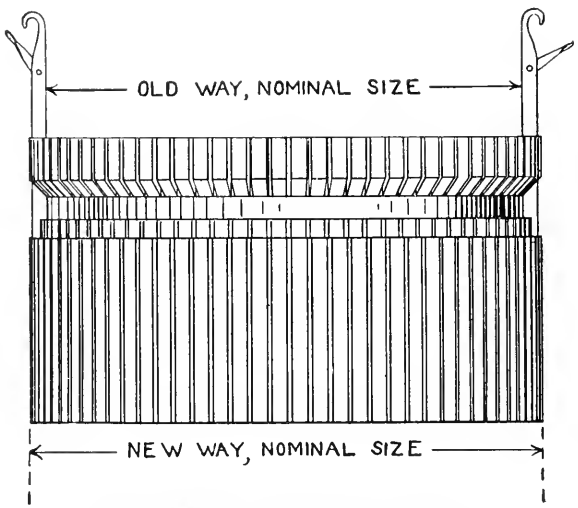


Fig. 28. Measurement of Knitting Machines.

ing the stitch. The needles are so arranged that every alternate row in plain-rib work is reversed (Fig. 29), thus making both sides alike. Ribbed work requires two banks of needles; the function of the second bank being to pull and loop the yarn in an opposite direction, thereby producing a thicker and more elastic web.

Useful modifications of plain-rib fabric are often obtained by varying the movement over the cams; of one or both sets of needles by leaving out certain needles in one or both sets; and by a combination of these expedients, as shown in Fig. 30.

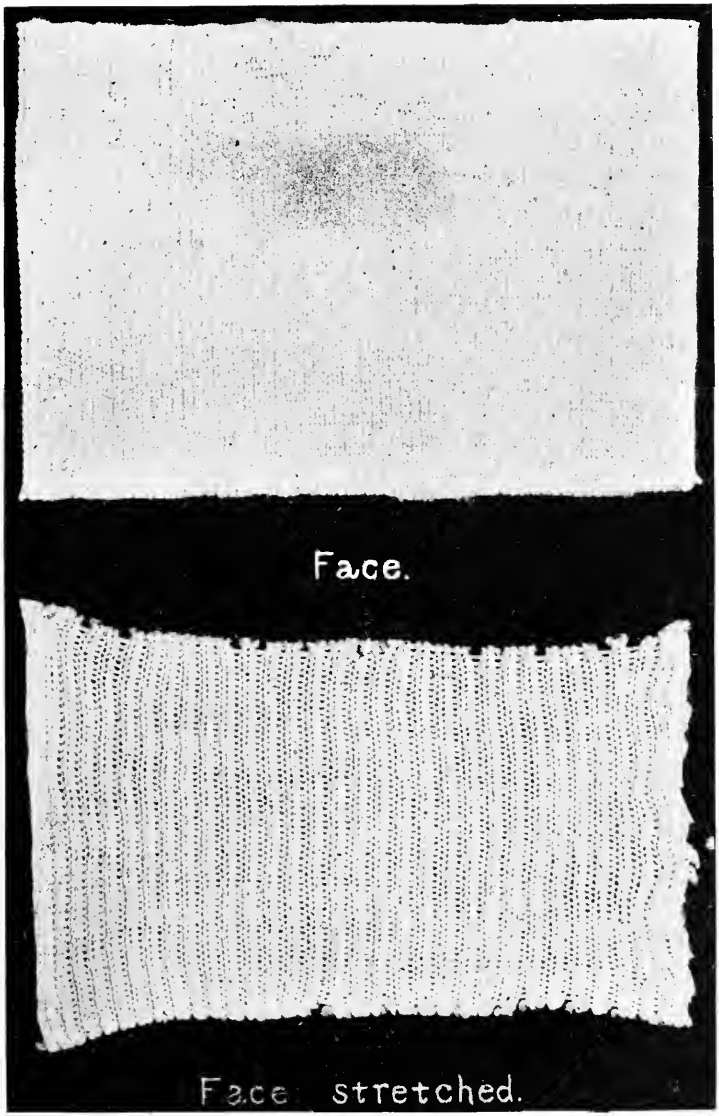


Fig. 29. One-and-One Fabric. Face and Back Alike.

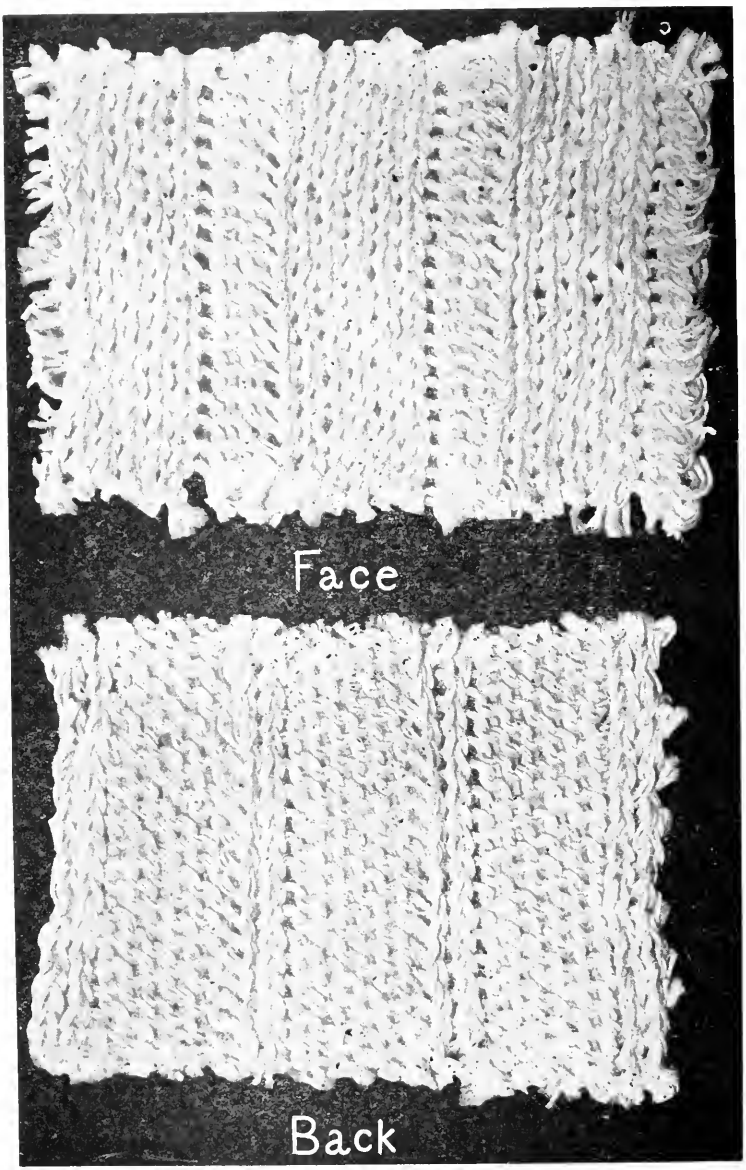


Fig. 30. Six-and-Two Plain Rib.

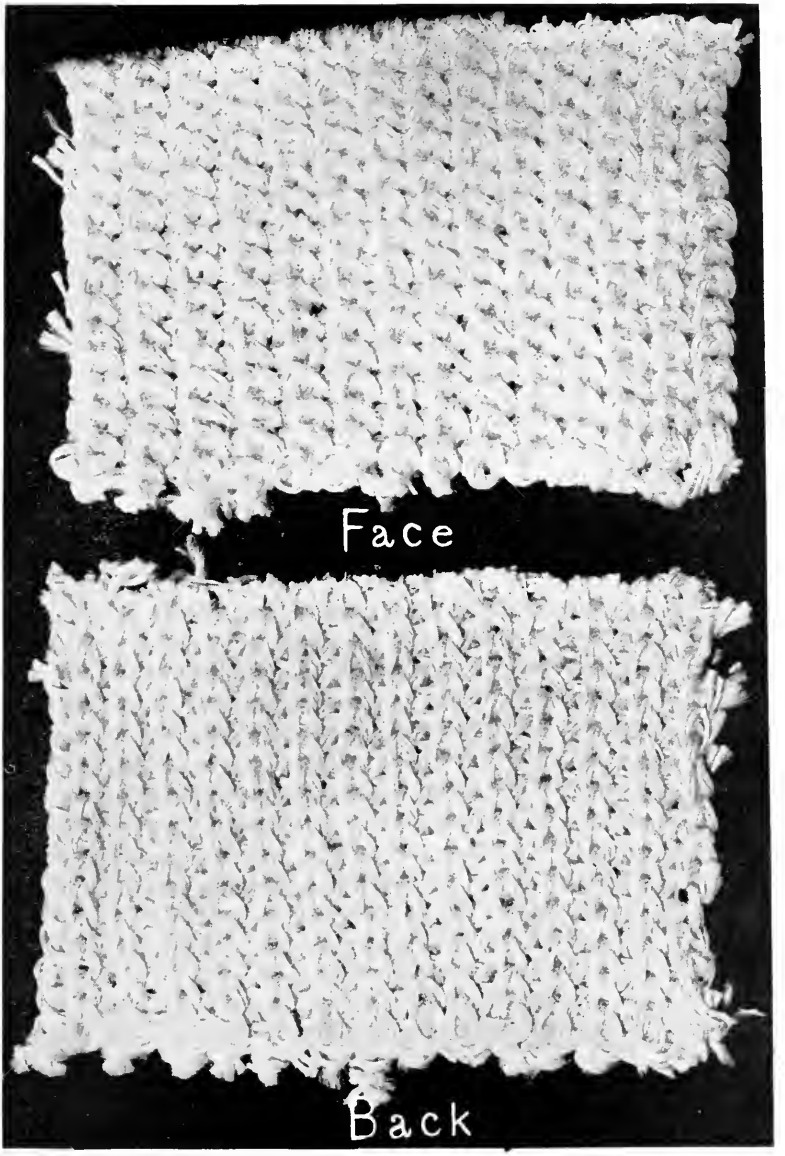


Fig. 31. One-and-One Tuck Stitch.

In knitting by hand, a latch needle will knit, tuck or purl the stitch. When *knitting* the stitch, the needle takes a new loop of thread and casts off a loop onto it, forming a completed stitch. When *tucking* the stitch, the needle takes the new thread into the hook but does not cast off the partly formed stitch. When *purling*, the needle neither takes the new yarn nor casts off the old loop, but retains the stitch previously made by it.

The most commonly used of these modifications of the plain-rib stitch are the tuck stitch, variously called half-cardigan, royal rib or sweater stitch, and the tuck stitch known as the cardigan stitch.

The Half-Cardigan, or Royal Rib Stitch (Fig. 31), is usually made by projecting the needles of the inside set not quite far

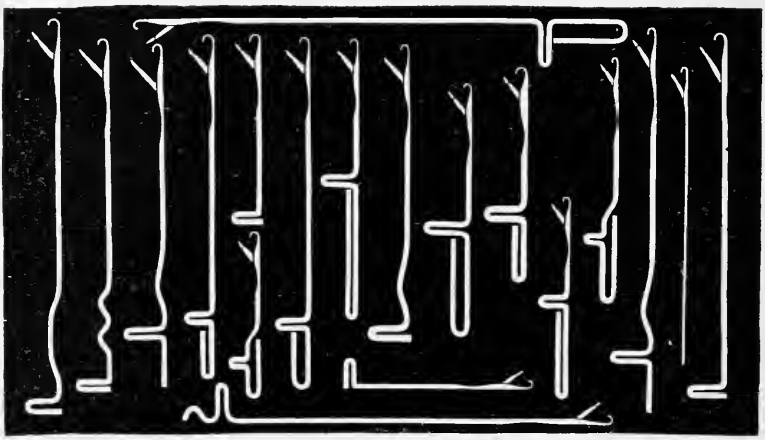


Fig. 32. Latch Needles.

enough on alternate feeds (or if a single-feed machine, on alternate revolutions) to cast off the partly formed stitch or loop in the latch over the end of the latch. As the latch cannot close with the stitch on it, the loop, instead of passing off when the needle is drawn in by the stitch cam, slides back into the hook of the needle and is retained with the new loop which is taken by the needle. The other feeds are knitting plain, and of course cast off the tucked loop with the other, making one complete stitch for each *two* feeds. The needles of the outside set are knitting plain, but two of the loops made by them are tied together by one double loop of the inside needles, widening and

Fig. 33. Lace or Open Work Effect.

thickening the fabric without destroying the characteristic elasticity of rib goods.

This is the method commonly used for shaping ladies' underwear, the machines being made to automatically change the position of cams to make the bust and skirt on the royal rib, while the waist, band and cuffs are on the plain stitch. (See Fig. 25.) Sweaters, also, are made with the body a half-cardigan stitch; and neck, tail, cuffs, etc., a plain rib, or some fancy stitch.

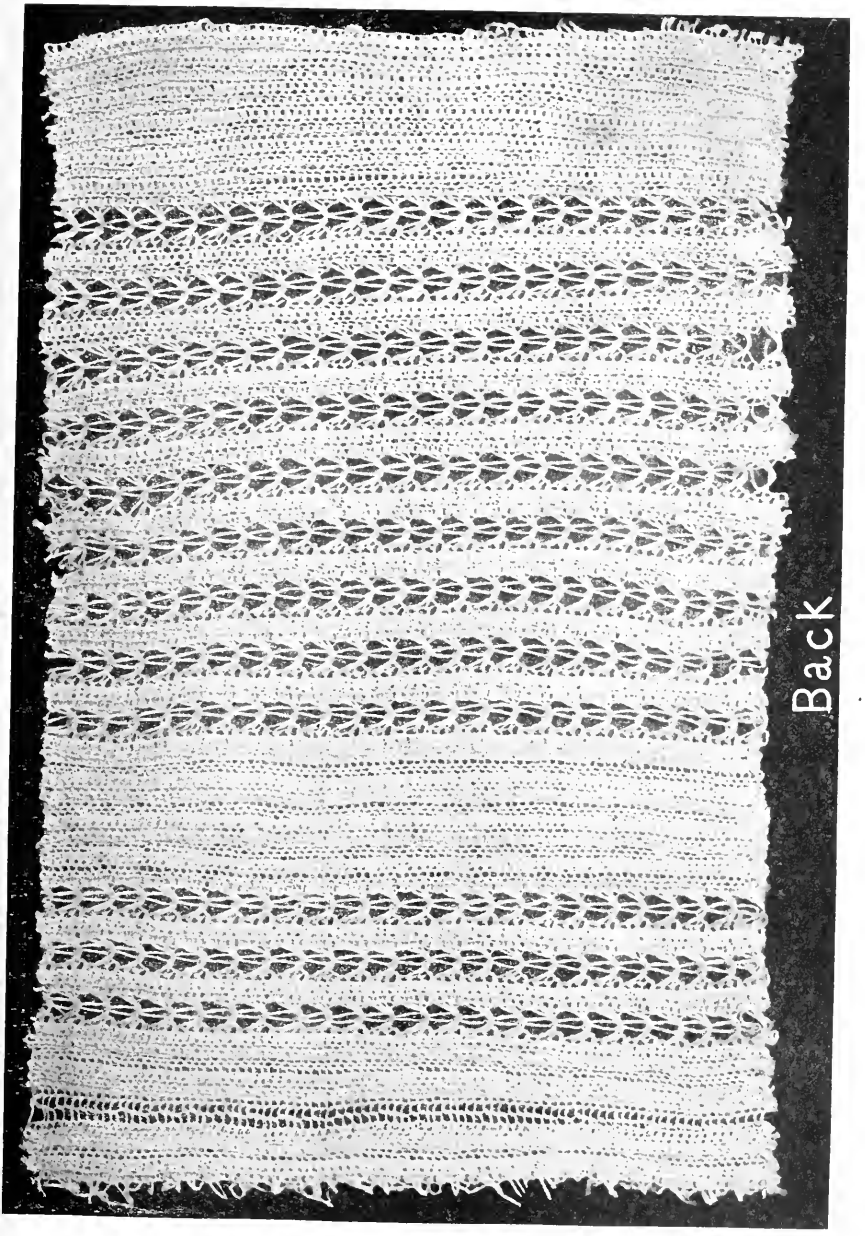
The Full Cardigan is made like the half-cardigan, on the inside needles; but in addition, the outside needles are also tucked on each alternate feed. The two sets of cams are arranged so that on the feeds, when the inside needles are tucking, the outside needles will cast off, and *vice versa*. This gives a larger, looser fabric than even the half cardigan, and is used extensively for cardigan jackets, etc.

It is customary to speak of the tuck stitch, but the needles do not form a complete stitch when tucking, and a tuck stitch is in reality *one or more tucks combined with a plain stitch*.

As will be seen from the above, the number of tucks which can be put in a needle without clearing is limited, and though for fancy effects, two, three, four, or sometimes even more tucks are placed in the needle hook at a time, the cams should be watched carefully to note that the clearing cams are working perfectly, otherwise the result will be disastrous.

Another use of purling is to make a fancy effect in the color design, or some special stitch similar to the pineapple stitch.

In Knitting Rib Fabric, needles are frequently left out of one or both sets at certain intervals around the machine, especially on ladies' underwear and hosiery. This gives a different appearance to the fabric, and to distinguish these different fabrics, they are known as 1 and 1 rib, 2 and 2 rib, 3 and 2 rib, 6 and 2, etc. The plain-rib fabric with every needle in both cylinder and dial, makes the 1 and 1 rib. Where there are two needles in the dial, then two in the cylinder, with an interval of two left out between each pair, it is known as a 2 and 2 rib. Where two are in the dial and two in the cylinder, with an interval of one between each pair, it is also called a 2 and 2 rib; in some localities it is known as two-needle line work. A fabric made with three needles in each plate, with an interval of one needle, is called three-needle line work, etc. Frequently the dial needles are



Back of Fig. 33.

set two in and one out, with all the needles in the cylinder; the effect produced being called a 2 and 1 rib.

Sometimes, on underwear especially, the needles are set, say for a 2 and 2 rib part way around the machine, and perhaps a 5 and 3 with the remaining needles. In many underwear mills, these "needle-out" effects are all referred to as *Richelieu* ribs, while in others, the name *Richelieu* designates a particular variety of needle-out work, oftentimes 5 and 3. As suggested before, these "needle-out" effects are often combined with the tuck stitch for producing the elegant lace effects, as illustrated in Fig. 33.

Double work in knitting consists merely in running two threads where one is ordinarily used. Coarser and heavier needles are required and a wider gauge for the needle cylinder. Fancy effects are obtained in double work by running two colors instead of one, the tendency being for one thread to twist around the other, thus making fancy double and twist work.

CONE WINDING.

The proper presentation of yarn to the knitting machine is one of the most important factors in the production of knit goods, and is, in a measure, more important in connection with the latch-needle machines than with spring needles. In the case of spring needle machines, where the bobbins rest on racks below the cylinders and near the floor, they may be made very large without other difficulty; but with latch-needle circular machines, where the yarn is placed on a rack above the cylinder, it is desirable to have as much yarn as possible in a small, light package.

The use of the paper tube to wind on, instead of the heavy winder bobbin, permits of the greatest quantity of yarn with the least weight, and winding machines have reached such a degree of perfection that the yarn is built into cones of uniform taper and tension, which give a free delivery to the knitting machines.

Universal Winder. It is customary for the yarn manufacturers to furnish yarn on the cop, although they sometimes re-wind it and furnish it in cones. When shipped to the knitting mill on cops, it must be wound on bobbins, or into cones; preferably the latter. The following is a description of a cone winder for this purpose: Fig. 34 represents the Universal Winder, ready for use in the knitting

mill for winding from the mule cop; and Fig. 35 illustrates the character of the wind and the shape of the cone. The yarn is laid in a regular succession of coils and layers; the same number of coils in

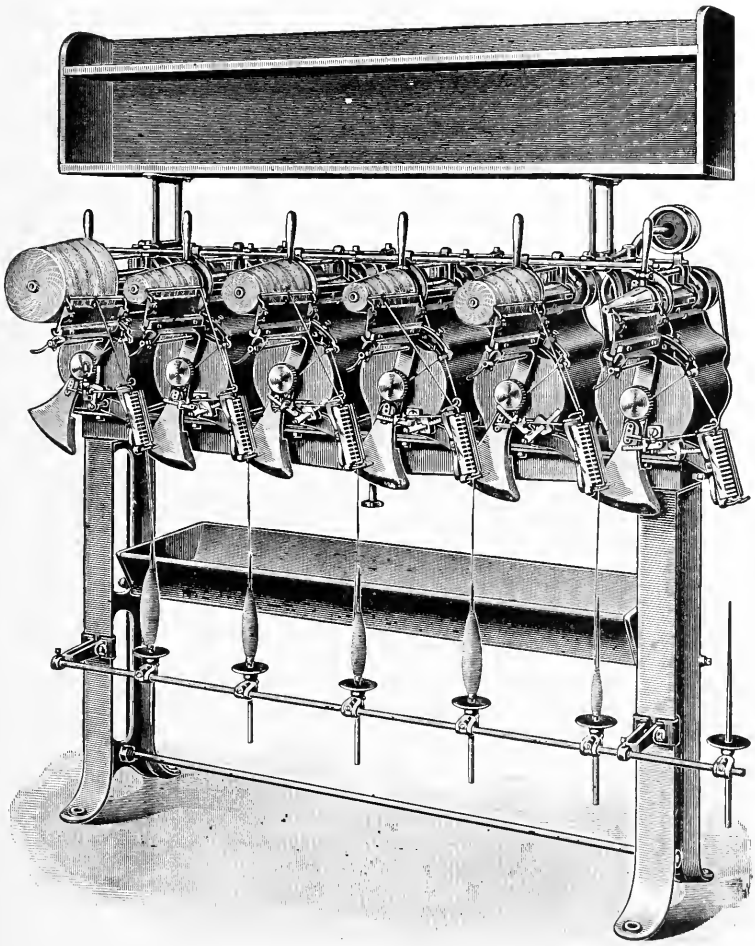


Fig. 34. Universal Cone Winder.

each layer. The successive coils are laid evenly, without crushing, or displacing the twist. Every coil is reversed at each end of the cone, passing back at a uniform angle, crossing every other previously laid coil, and binding it into place.

Guide. The guide delivering the yarn close to the surface of the cone, prevents any coils from passing beyond the point of reversal and slipping across the end of the cone to produce "cobwebs." The spindle is rotated at uniform speed; the yarn guide rests lightly against the surface of the yarn, and the number of coils in each layer about the cone is uniform. The same thickness of yarn is built up at each end, forming a cone with uniform taper, from start to finish.

Tension. The tension on the yarn in this process of winding is applied by passing the yarn between a number of polished steel blades, the pressure of which is graduated to produce uniform stress on the yarn. Fig. 36 shows the yarn controller, which is adapted to all sizes and qualities of yarn. The interlocking fingers, between which the yarn passes, are made of thin steel with polished oval surfaces, bearing on the yarn alternately to deflect it from a straight line, and causing it to be delivered uniformly to the winding spindle. The position of the steel fingers can be adjusted to properly control the different grades and sizes of yarn.

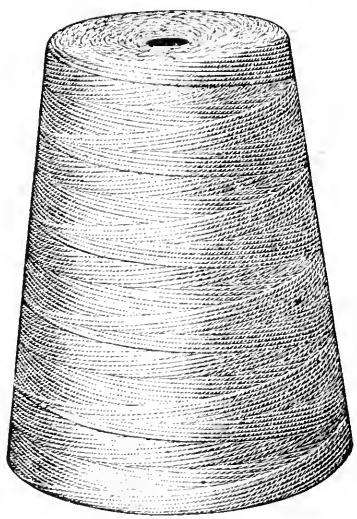


Fig. 35. Universal Cone.

The rapid traverse of the yarn through the controller causes it to act as a yarn cleaner, throwing off the specks, dirt and loose slubs, and thereby improving it. As the speed of the yarn increases in proportion to the size of the cone the pressure of the tension blades against the yarn is *automatically reduced*, thus building the cone with a uniform density. When the winding spindle stops, the tension blades are automatically thrown apart, and the tension remains open until the spindle is again started.

Gainer Mechanism (Fig. 37). *The upper*, or *winding spindle*, being driven at a certain speed, is connected by means of a belt *o* with a small pulley on the end of the spindle, which carries the pinion W meshed with the gear *u* which is attached to the lower shaft *l* driving the cam. The speed relation is six to one, so that while the yarn

guide is moving from one end of the cone to the other and returning to its original position, the top shaft revolves exactly six times, when the diameter of the two pulleys is exactly the same.

A *micrometer adjustment* is provided by means of a split ring *r* on the top pulley *m*. This split ring is supported on the three arms *s* projecting from the hub of the pulley. These pins rest against the bevelled end of the threaded nut *t*. By turning this threaded nut to the left, the pins *s* move down the bevel, so that the ring *r* contracts

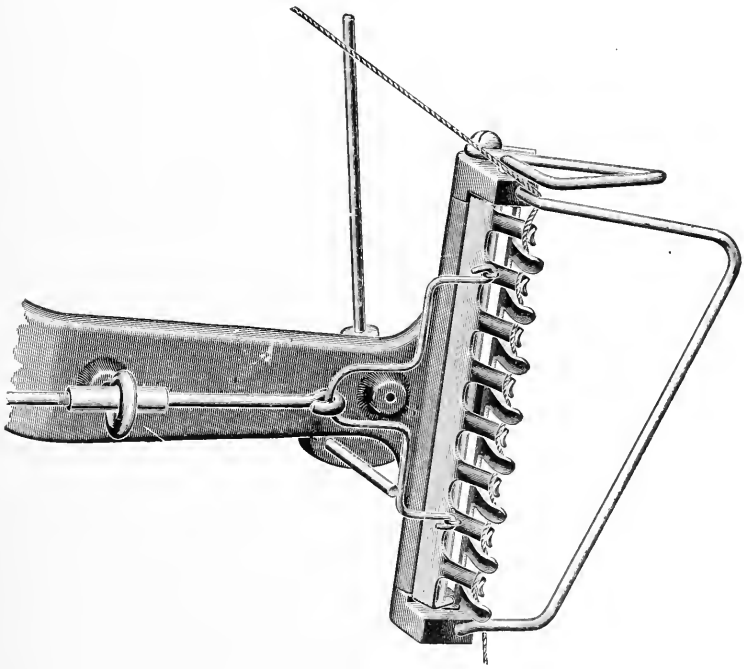


Fig. 36. Yarn Controller.

slightly, thus reducing the diameter of the upper pulley and changing the speed relationship. With this adjustment, the top shaft completes the sixth revolution, and has started upon the seventh before the guide has made a complete reciprocation and reached its starting point. The effect of this is to cause the yarn to cross over the preceding coils at the end, and form a regular succession of spirals, building up the entire cone.

To close the wind for finer yarn, the nut should be turned to the right. This adjustment by means of the threaded nut *t* is so delicate as to admit of winding the very finest yarns without "over-

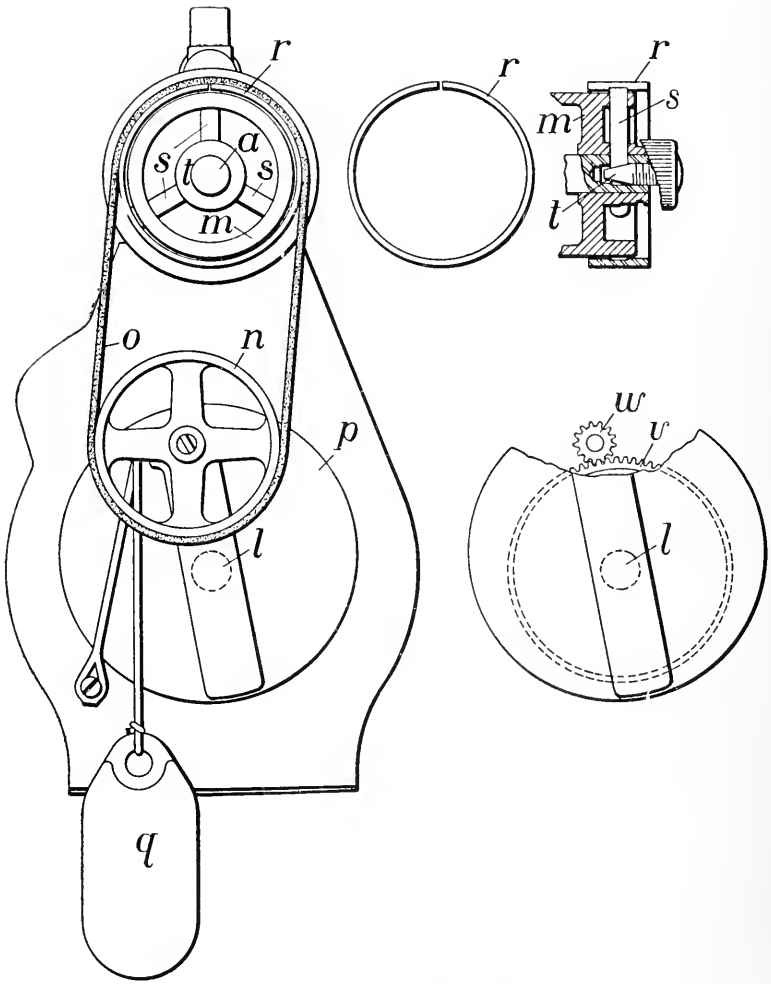
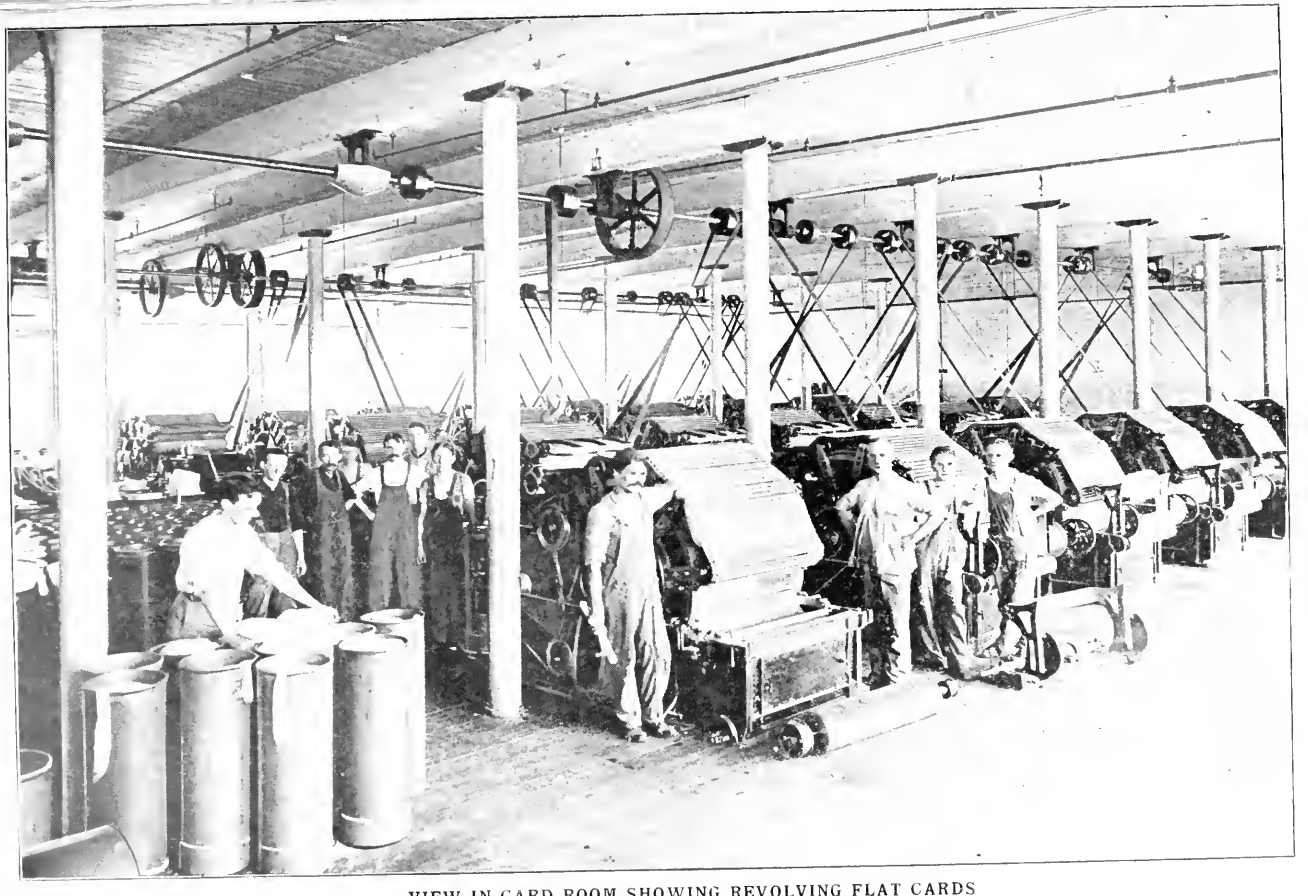


Fig. 37. Universal Gainer Mechanism.

rides," or leaving spaces between, forming one compact, uniform package from start to finish. The weight *q* holds the belt under uniform strain to insure accuracy at all times. The gear pinion *w* and the gear *u* are enclosed in a casing and run in oil, thus assuring



VIEW IN CARD ROOM SHOWING REVOLVING FLAT CARDS

Shaw Stocking Co.

durability and requiring less power. The top shaft *a* is oiled by means of the reservoir in the top of the frame, which automatically carries the oil through the bearings and returns it to the reservoir.

The threading of the machine and the arrangement of the tension is shown at Fig. 38, which is a sketch of a section of the front of the machine.

When starting the machine in operation, place the paper cone upon the spindle and draw the lever *x* forward towards the end of the spindle. This expands the holder and holds the cone tube firmly in place. The yarn is then drawn from the supply spindle at the base of the machine, and passed between the tension blades *d*, *d'*, over the pick-up bail *y*, and passed once or twice around the paper cone on the spindle. The guide *b*, supported by the swinging frame *c*, should be moved forward against the surface of the paper cone, as shown by the dotted lines in the cut, and the machine started into operation by pressing the lever *x* to the right.

It is essential that the guide rest against the surface of the cone, as otherwise the winding will be defective. It is not necessary to place the yarn in the groove of the guide, as the guide coming in contact with the yarn when the machine starts, will push it up the incline at either end of the pick-up bail and automatically thread itself.

Adjusting the Pressure. The frame *c* is pivoted on the cam shaft, and the lower end *c'* is counterweighted so as to bring the guide against the surface of the cone, while it is being wound with a slight pressure. This pressure can be varied for different classes of material by shifting the bent arm of the lever *f* in the holes *g*. The greatest pressure is obtained by placing the bent end of the arm in the lowest hole. For soft hosiery yarn, it is desirable to use the top hole, this giving the lightest pressure. Connected with the rod *f* is the lever *e* and a movable weight *j* on the lever. To increase the pressure of the guide against the cone, move the weight *j* toward the outer end of the lever. The softer and finer the yarn, the less pressure is required, and for knitting yarn, the pressure should be reduced to the least quantity.

Adjusting the Tension. The tension upon the yarn is regulated in two ways: The yarn passing between the series of blades *d*–*d'*, is deflected from a straight line by a slight pressure of the blades,

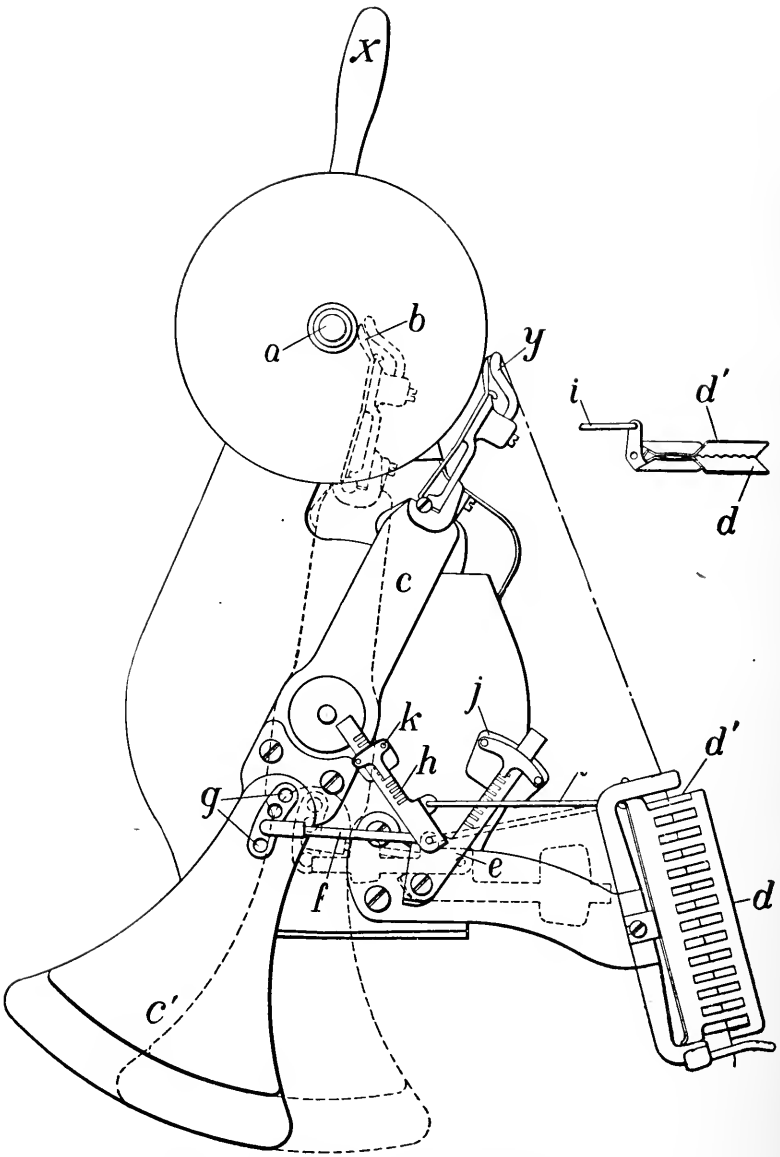


Fig. 38. Universal Differential Tension Mechanism.

and sufficient tension placed upon it to keep it in line for uniform delivery to the cone. On the lever *h*, which is connected to the movable tension blade *d* by means of the link *i*, is a weight *k*, which can be shifted to increase or diminish the pressure of the blades against the yarn. With the weight at its lowest position on the lever, there is a very light pressure of the blades against the yarn, on its passage from the supply cop, or bobbin, to the winding spindle. When it is desirable to break out soft spots in the yarn, the tension should be increased.

The Effect. When the machine is first started in operation with the paper cone bare, the frame *c* is in the position shown by the dotted lines, and the tension arms *h*, and *e* lie in nearly a horizontal position, thus giving the greatest pressure and tension at this point. As the cone increases in size, the guide is pushed back gradually, finally reaching the position shown in the sketch with the two levers raised nearer to a vertical position. The spindle speed of the machine being constant, there will be more and more yarn drawn on at each revolution until a full-sized cone is wound. The increase in speed in drawing the yarn through the tension blades increases the strain upon the yarn, if the pressure of the blades were to remain the same; but the change in leverage, as the guide moves back, automatically reduces the pressure of the blades to compensate for the increased rate of speed of the yarn, thus winding the outer coils of yarn under no more tension at high speed than inner coils are wound at a slow speed. By means of this differential tension, the machine can be adjusted to wind very soft twisted knitting or backing yarn with absolute uniformity.

The winding spindles should be run at a speed not to exceed 1,200 revolutions per minute, in winding soft spun yarn.

CIRCULAR RIB KNITTING MACHINES.

REVOLVING NEEDLE CYLINDER.

The type of this style of machine (Stafford & Holt) illustrated in Fig. 39, has the outlines usually followed by builders of these machines. It rests on four legs, secured to the bedplate A, which supports the housings Y and Z on opposite sides of the machine. These housing plates support the cam ring B in which the needle cylinder revolves, and on which the cam system for vertical needles

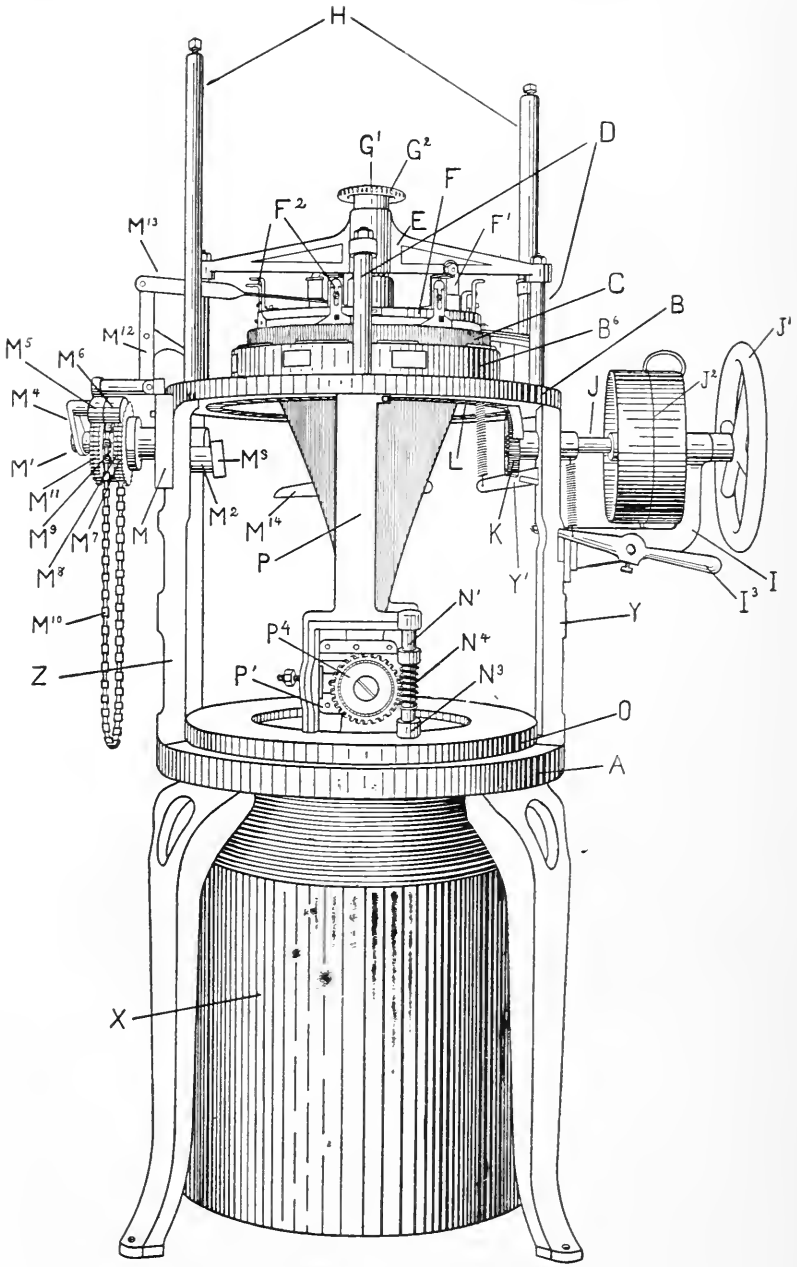


Fig. 39. Latch Needle Circular Knitting Machine.
Revolving Needle Cylinder.

is arranged. On this cam ring are secured four studs D, to support the dial arch E for holding up the cap, on which is arranged the cam system for the radial needles, and the dial. The bobbins are held on a frame, the supports H of which are secured to the cam ring also,

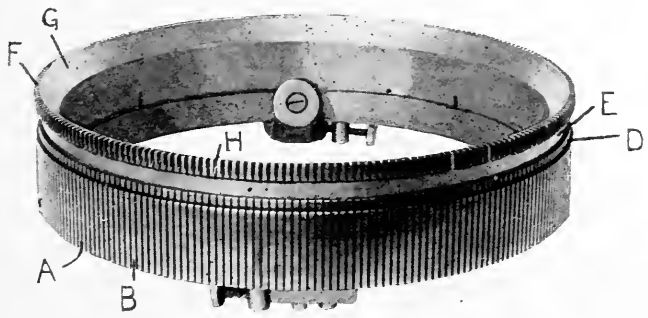


Fig. 40. Needle Cylinder.

To the right housing plate Y is secured the driving shaft bracket I, which makes the outer bearing for the driving shaft, and on the shaft J are tight and loose pulleys between the bearings. Outside the

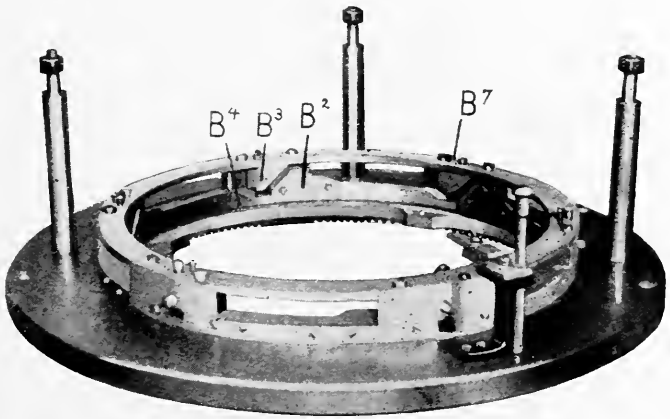


Fig. 41. Cam Ring.

shaft bracket bearing is a hand wheel J′, for turning the machine by hand when occasion requires. Attached to the shaft arm is a belt shipper with belt and handle. On the shaft, inside the housing, is a bevel pinion K, which, meshing into the needle cylinder gear L, rotates the cylinder.

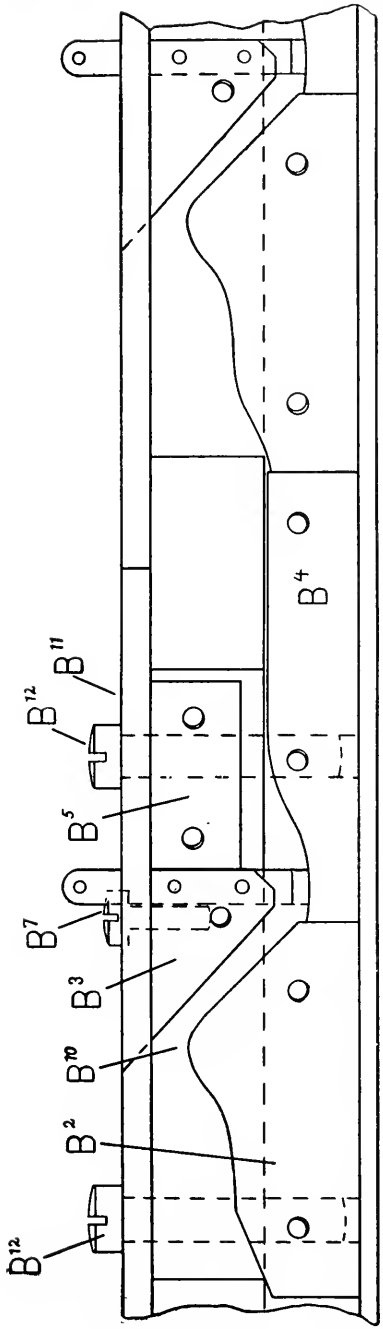


Fig. 42. Projection of Cam Ring Showing Disposition of Cams.

Needle Cylinder. (Fig. 40). The cylinder needles are reciprocated vertically in slots in the periphery of the needle cylinders, as shown in the illustration. Needle cylinders are usually constructed from steel forgings of good quality, as the requirements are very severe; the needle walls or lands should be hard enough not to jam too easily, and yet not hard enough to break. The cut across the face of the cylinder for the needle, as at A, is generally called the needle slot; the part B, between the slots, is called the land, or sometimes, the needle wall. The slot is widened at the top, as at H, to clear the yarn when drawn into the slot by the needle. This widened part is often called the *sinker cut*. The grooves at D and E are called the gib, and clearance counterbores. The narrow radial face at F is called the top, and the adjacent face G, the bevel of the cylinder.

It is important that the cylinder be *perfectly concentric*, that the needle slots are exactly the same depth, accurately spaced, smoothly cut, and of such width that the needle slides freely back and forth without side play. The counterbore should be of such a depth that when the gib sets against it, the

needle just passes freely under it. The sinker cut should be smooth, of exactly the same depth as the slot, with the top edges of the cylinder and lands carefully rounded so not to cut the yarn when drawn through.

Cam Ring and Cams. Fig. 41 shows the cam ring and the arrangement of cams on its inner surface, but is more clearly illustrated in the projection of cam ring, Fig. 42. The cam B^2 is the rise cam;

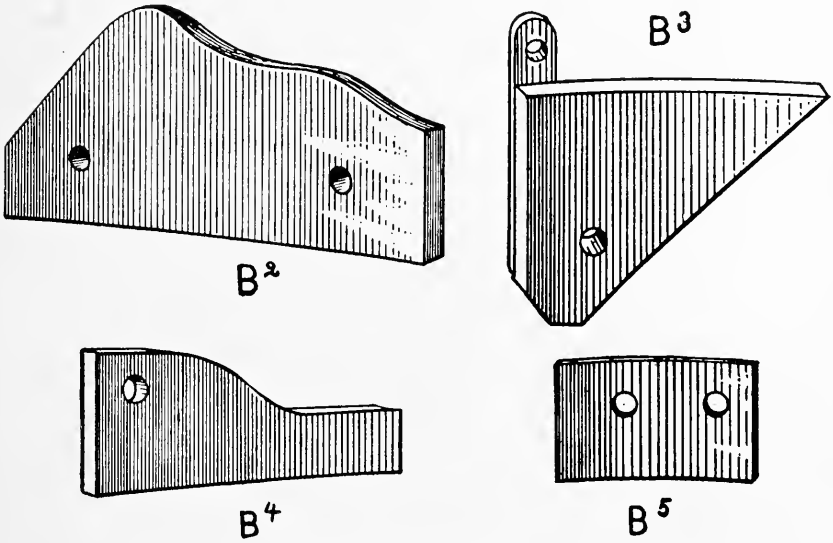


Fig. 43. Cylinder Cams.

B^3 the stitch cam; B^4, the fill-in cam, and B^5, the guard cam, all shown in detail in Fig 43. These are all stationary except the stitch cam, which can be adjusted for slackening or tightening the stitch by means of adjusting screw B^7. The stitch cam extends up into the gib, which is slotted to receive it, so that when it is pushed up or down, the extreme point is covered by the gib, and a needle that should happen to be drawn beyond its normal limit, will be forced into its proper position on striking this cam.

These cams are usually made of the best quality of tool steel and tempered very hard Their working faces should be very smooth, and should come in contact with the needle close to the cylinder, which should be a nice running fit to the circle formed by the cams.

The first rise on the rise cam opens the needle latch, and should be long enough to get all the latches opened before reaching the yarn guide, but comparatively shorter than the rise cam on the dial. The stitch cam should be as steep as practicable, especially that part which actuates the needles from the time the yarn draws through the dial needles. One end of the fill-in or connecting cam is made low enough for the needle to pass around the stitch cam, and the other end high enough to return the hook of the needle about $\frac{1}{8}$-inch above the cylinder top, for convenience in starting the machine, and also to assist holding the work in position on the dial needle when it starts to advance.

Needle Dial. Fig. 44 represents the needle dial. It is practically a duplicate of the needle cylinder, except the shape, which

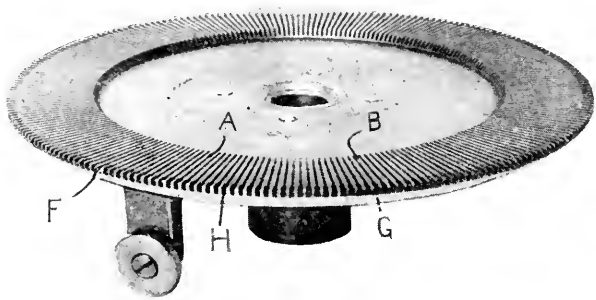


Fig. 44. Needle Dial.

is made to accommodate the radial needles, and the method of holding it in position. The corresponding parts of the needle plate are known by the same names as those of the cylinder. It is essential that the bore should be perfect, and be a nice fit on the dial shaft, in order that the upper surface with the needle slots will revolve perfectly true on the shaft.

Drivers. On the under surface of the dial are the drivers, usually placed diametrically opposite, abutting against a similar pair fastened to the inner surface of the cylinder. As the fabric is being knitted, it passes between a pair of these drivers, placed on each side of the machine, and as the whole strain of driving the dial needles against their cams is transmitted through them, it is essential that these drivers be very smooth, or preferably, that one or both be provided with rollers like those shown in Fig. 44. It is also necessary

that the needles in the dial and those in the cylinder, work in the center of spaee between the needles of the opposite plate, and as the fabric on the machine is varied in thickness, either the dial or cylinder drivers are made adjustable, especially in large machines. Fig. 40 represents a cylinder with adjustable drivers.

Dial Cap and Cams. The cams on the dial eap correspond closely to those in the cam ring, the shape being changed to suit their position. In Fig. 45, F^3 shows the rise cam; F^4, the work cam; F^5,

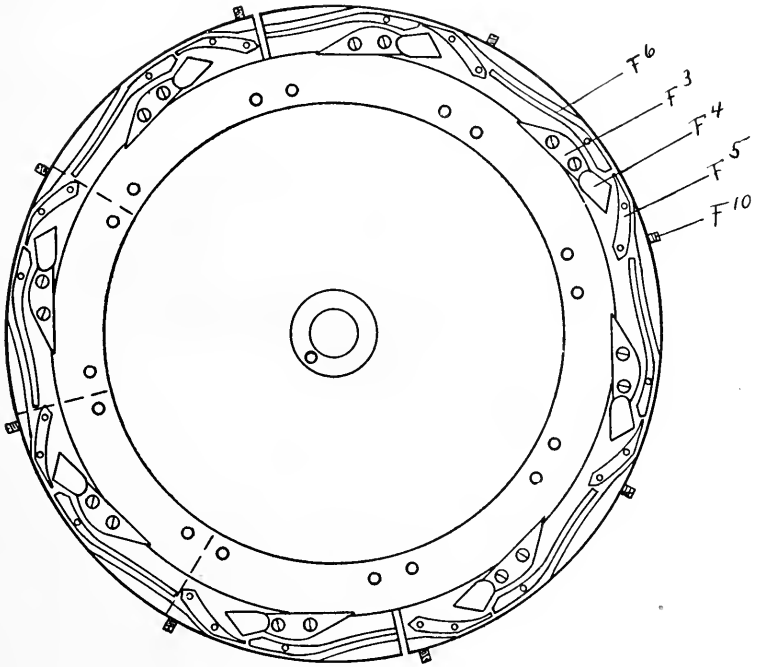


Fig. 45. Dial Cap.

the stitch eam, and F^5, the guard cam, and their locations. Fig. 46 shows each cam in detail. On plain machines, cams F^3 and F^4 are often made in one piece corresponding to cam B^2 in the cam ring; but in automatie machines, the tuck stitch which widens the fabric is made by moving the outer point of the rise cam back to prevent the loop in the hook from slipping off the latch. The needle retains this loop in the hook, and on the next feed takes another loop, both

passing over the latch together, thus combining two cylinder stitches with one dial stitch.

The *dial* rise cam should start to push out the needle slightly in advance of the *cylinder* rise cam, as the cylinder needles are in a better position to assist in holding the stitch in position. The dial stitch cam is made adjustable to tighten or loosen the stitch, and should be of a shape that will not close the latches too quickly on the yarn that the cylinder needles are taking, but will complete the stitch as soon after as possible.

The *guard cams on both cylinder and dial* are used solely to prevent the needles getting misplaced. The yarn is fed into the cylinder needles, which draw it into the hooks of the dial needles, and the position of the two sets of cams in respect to each other is very important, as results can be varied widely by changing them. The above remarks in regard to cams have reference to underwear as generally made.

To *vary the respective adjustment* of the cam ring and the cap plate, the dial stop F^1 (Fig. 39) is provided, which is fastened to the top of the dial cap and has a set screw abutting against one of the arms of the dial arch. The dial shaft G^1 fastened in the arch, supports the cap and dial. This cap is fixed to the shaft by means of set screws in the hub and a stop on the dial cap resting against an arm of the arch. The dial is supported on the shaft by a collar secured to the shaft on which it revolves. The dial shaft with the cap and dial is adjusted vertically by means of the dial nut G^2. The dial is rotated by means of two lugs in contact with lugs on the cylinder. The thread guides are fixed to the thread carriers which are fastened to the dial cap F.

On the under surface of the dial cap are arranged the cams for actuating the radial needles. These consist of the rise cams F^3; the work cams F^4; the stitch cams F^5, and the guard cams F^6. (See Fig. 45.) A set of these cams constitutes a feed for each thread used in the machine, excepting the stitch cams, which are adjustable for different stitches.

The Cap Plate, Fig. 47, represents the top side of the cap plate F and is the reverse side of Fig 45 F^7 is the cap plate ring, to which are secured the cap plate straps F^8, which move the cams, to which they are connected, in and out for the purpose described above.

In the ring F^7 is fixed a stud F^{10} to which is fastened the strap or connecting rod M^{13} (Fig. 39), which transmits motion from the automatic mechanism to the cams for changing the character of the stitch. The ring F^7 is fitted loosely around the hub F^{11} of the cap, and the plate straps are connected to the ring by means of the studs F^{12}.

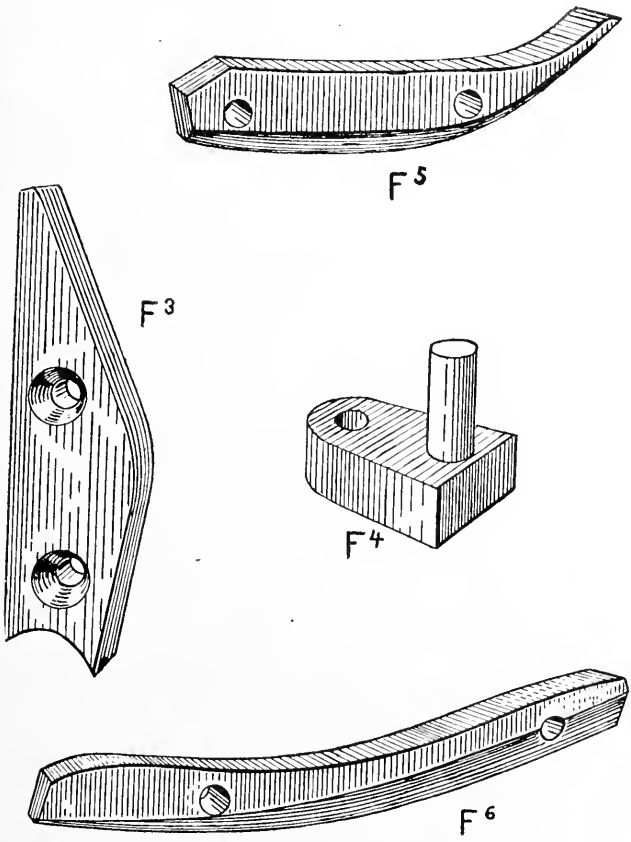


Fig. 46. Dial Needle Cams.

The several screws, heads and holes show the means employed to secure the cams on the reverse side. The cap is fastened to the dial shaft G^1 by means of set screws through the hub F^{11}.

Automatic Knitting Mechanism. On the automatic machine, the work cams are connected by a mechanism as follows: (See Fig. 39.) On the left housing plate Z is fixed the bracket M,

in which is journaled the shaft. On the inner end of the shaft is the chain drive lever M^2, with a stud roller M^3, and on the outer end of the shaft is the pawl lever M^4, carrying pawls M^5 and M^6. The bracket M has a projection in which is the bearing of the shaft M^1, and on the outside of which is journaled the idler ratchet M^7 nearest the machine. Outside of the idler ratchet is the chain ratchet M^8,

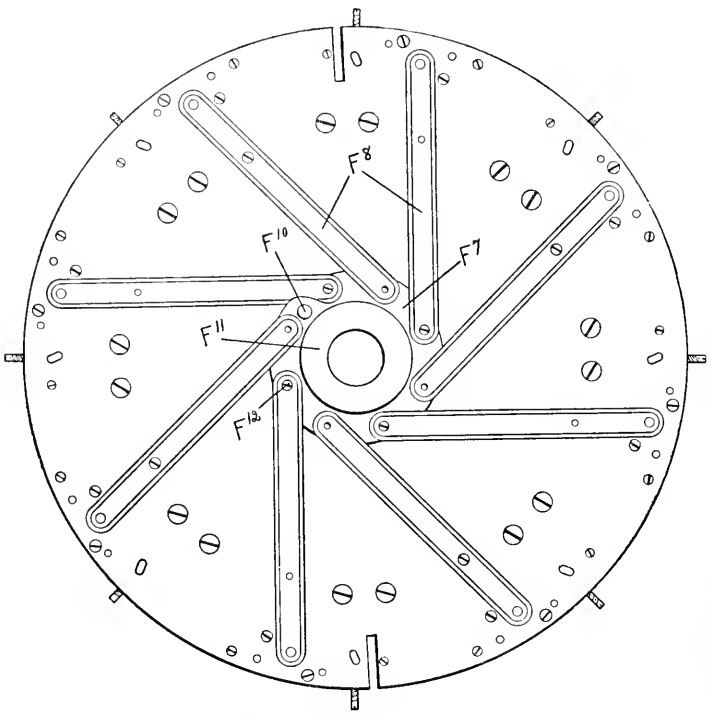


Fig. 47. Top Side of Cap Plate.

to which is fixed the sprocket wheel M^9 that carries the pattern chain M^{10}. Next to the chain ratchet is the cam wheel M^{11}, on the periphery of which rests the chain lever M^{12}, which is pivoted in the top of the chain bracket M. To the upper end of this bracket is connected a lever M^{13} that actuates the work cams in the dial cap by moving the cap plate ring F^7, the motion being transmitted by the cap plate straps F^8, which are connected by pins to the work cams, thus moving them in and out, as predetermined by the lugs on the pattern chain. The pattern chain is operated by the cam M^{14} on

the take-up arm, which raises the chain driver lever each revolution, and by means of a pawl lever, moves the chain ratchet and sprocket ahead one tooth, unless prevented by the idler ratchet, which permits the pawl to engage the chain ratchet only as predetermined.

The Take-up. (Fig. 48.) To the bedplate A is fixed the bedplate gear N, enclosed by the gear case O, which revolves on the bed-

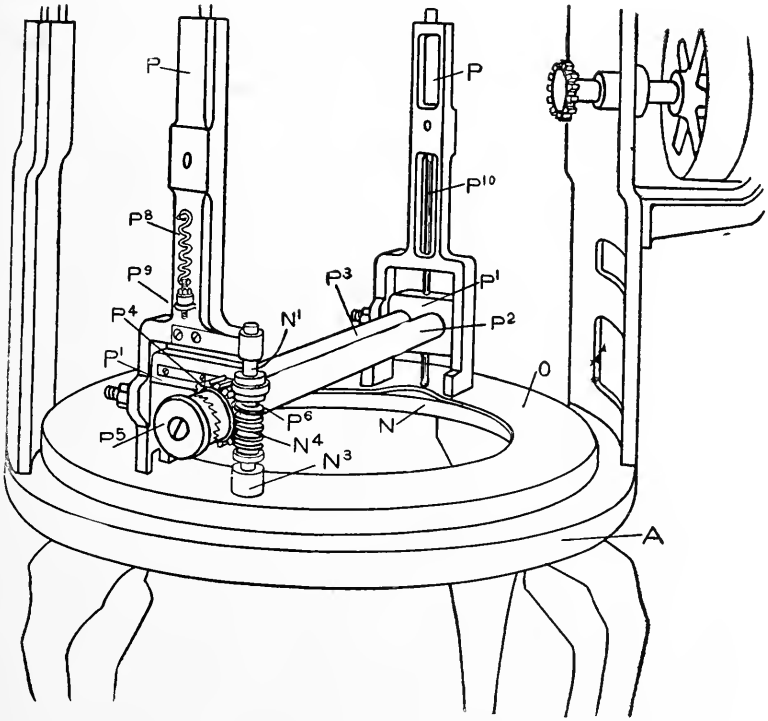


Fig. 48. Frame and Take-up.

plate, which carries a bearing for the pinion shaft N^1, on the lower end of which is a pinion N^2, meshing with the bedplate gear N. On the pinion shaft is fixed a single-toothed clutch N^3, and a worm N^4, journaled on the same shaft. The take-up arms P are supported on top of the gear case, the upper ends being in the cylinder gear L, by means of which the take-up mechanism is rotated. In the take-up arms are loosely fitted the bearing blocks P^1 in which are journaled

the take-up rolls P^2 and P^3. The rolls, which are fluted, are geared together at one end, and are held in yielding contact with each other by means of coil springs in adjustable blocks with set screws on both ends. At the opposite end of the drive roll P^2 is journaled a worm gear P^4, provided with a clutch P^5 feathered on the shaft and driven by the worm N^4 on the worm shaft, Fig. 49. The worm is supported by the arm P^6, fixed to the take-up bearing P^1. At the lower end of the worm is a projection to engage clutch N^3.

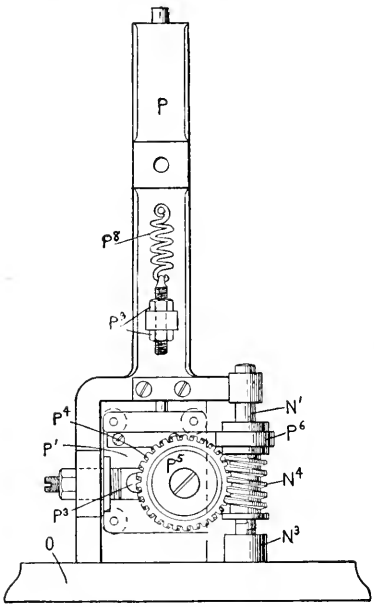


Fig. 49. Detail of Take-up.

The bearings P^1 have a certain amount of vertical movement, and by means of the arm P^6, carry the worm N^4 up or down. This movement is sufficient to disengage the worm from the clutch N^3 and when the shaft N^1 turns freely in the worm, no movement is transmitted to the take-up rolls; but when the bearings are lowered, so that the worm engages the clutch, motion is transmitted through the worm and worm gear, by means of clutch P^5, to the take-up rolls, and the fabric introduced between them is drawn away from the needles. It will be seen from the description that the motion of the take-up rolls tends to raise them and that they must have sufficient weight to keep the required tension on the goods. The coil spring P^8 and adjusting nuts P^9 are provided to regulate this. They can be attached to the rods P^{10} and made to increase the tension on the fabric, or turned around and attached to the take-up blocks directly, and adjusted to diminish the tension.

Bobbin Rack. Fig. 50 represents the bobbin rack. H is a casting with a hub, in the bore of which is held, by means of a set screw, a rod H^1 extending upward two or three feet and downward a few inches. At a distance from the center sufficient to give the required amount of room, a number of pins H^2 are set concentric

with the hub, and outside these another circle of the same number are similarly arranged. The bobbins are placed on these pins. On the upper end of the rod H^1 is fastened a hub H^6 in which are drilled as many radial holes as there are bobbin pins, and extending from each of these holes is a yarn hook H^3 of sufficient length to bring the center of each hook directly over its corresponding pin and bobbin. Also on the rod H^1, one above and one below rack H, are two guide discs H^4 and H^5, each drilled near its edge with as many holes as there are bobbin pins.

Automatic Stop Motion. Drive-bracket I, as shown in Fig. 51, is an angle casting, having at one face a foot which is secured to housing Y. On the other face is a boss, through which is a bearing registering with the bearing in the boss on the housing. Through this bearing extends the shaft J, having at one end the bevel pinion K and at the other the hand wheel J^1. Between the bearings are the drive pulleys J^2. In the bottom of the bracket is provided a bearing transversely to the drive shaft, through which is the small shaft I^1, on one end of which is the belt fork I^2, and on the other end, the handle I^3. The casting which forms the handle extends on the opposite side of the shaft far enough to reach through the housing Y and engage the trip Y^1. A coil spring Y^2 is adjusted to raise this projection of handle I^3, and a coil spring Y^3 is attached to trip Y^1, tending to hold it in contact with I^3. The shifter fork and handle are fastened to shaft I^1 in such a position that the normal action of the coil spring Y^2 is to hold the belt on the loose pulley, but by raising the handle the belt fork shifts the belt onto the tight pulley, and the extended portion of the handle catches under the end of the trip by action of spring Y^3 and is held in this position until the trip is depressed far enough to clear the handle,

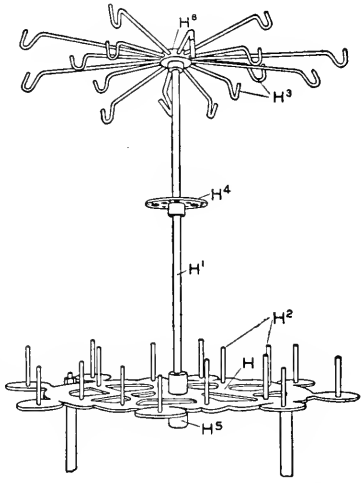


Fig. 50. Bobbin Rack.

when spring Y^2 returns the belt fork and shifts the belt to the loose pulley.

Hole and Bunch Detector. Fastened on top of the cam ring, directly over the end of trip Y^1 (Fig. 51), is the needle protector bracket Y^6, provided with latch Y^7 and finger Y^8. Through the top of the bracket is a bearing which is also carried through the bedplate. In this bearing slides the plunger Y^9, having on top a small handle or knob, and near its top, a channel or cross cut. This plunger is provided with a coil spring tending to force it downward, in which posi-

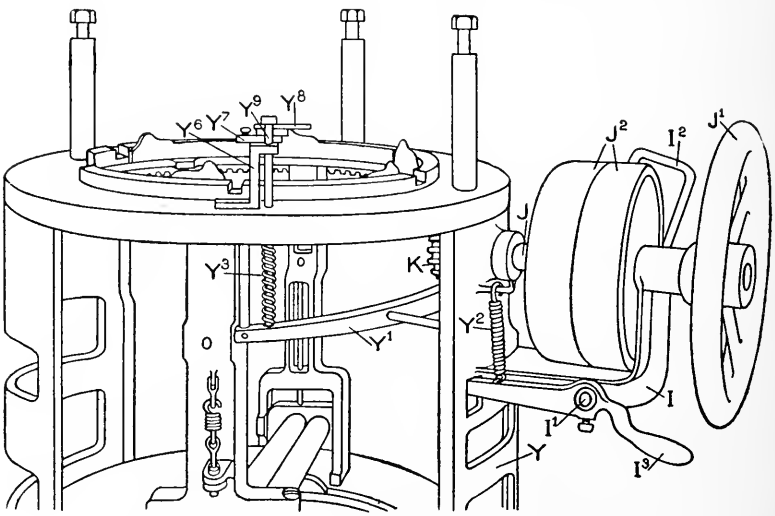
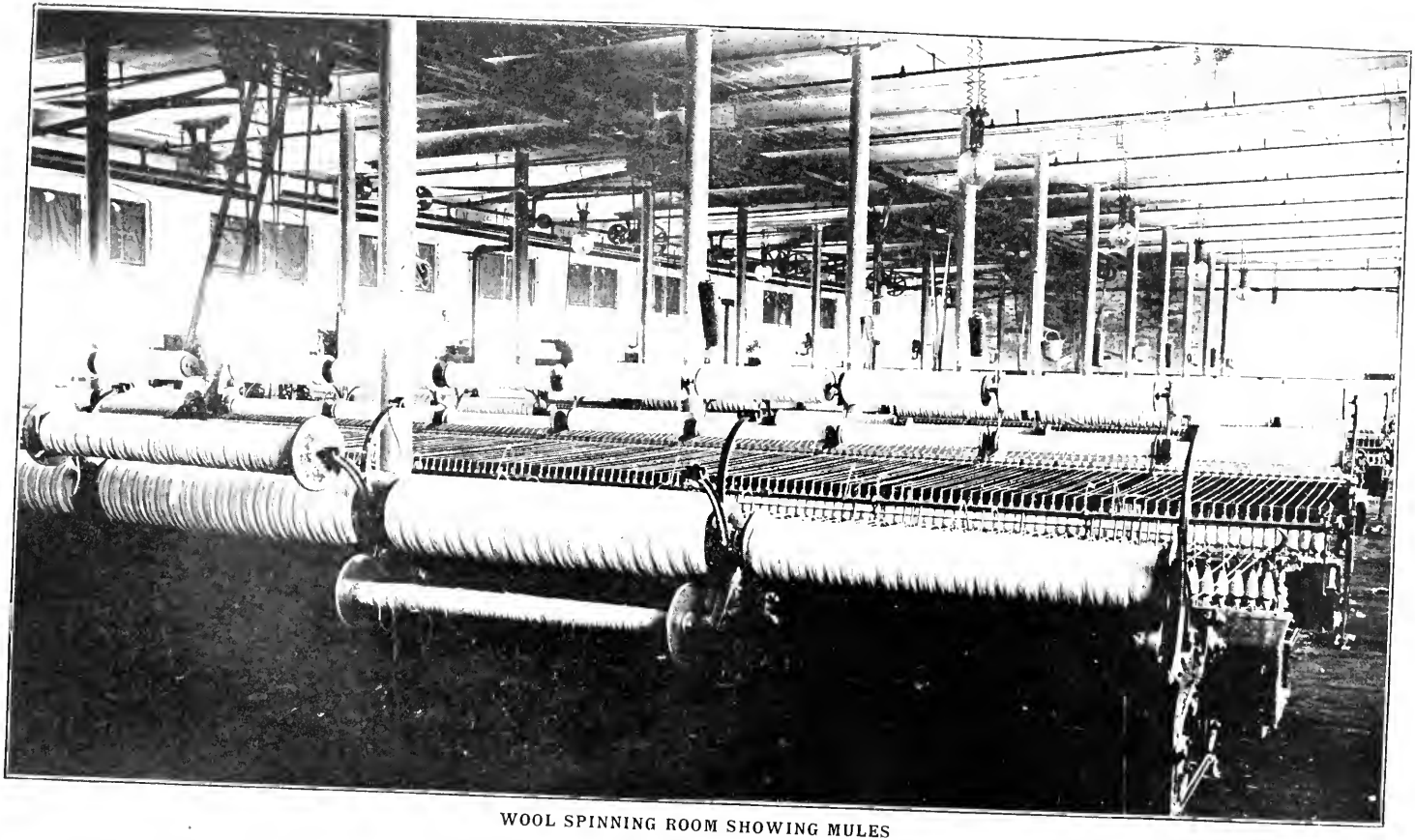


Fig. 51. Top Frame and Driving.

tion it rests on top of trip Y^1. The finger is fastened to the latch so that when its inner end stands between the paths of the ends of the cylinder and dial needles, just beyond the point where the stitches are formed, the channel in the plunger can be rested on the latch, the plunger having been drawn up beyond the trip. In this position, it does not interfere with the running of the machine in any way, but should a lump gather on the needles, or some other imperfection cause a needle to rise slightly above its normal position, the finger is caught, swung around and away (carrying the latch) from the plunger resting on it, and the spring causes it to descend, striking the trip and stopping the machine.



WOOL SPINNING ROOM SHOWING MULES

Utica Knitting Co.

In Fig. 52, B represents the cam ring of the knitting frame, C the cylinder and F the dial. Y^6 is the cast-iron bracket fastened to the cam ring by screws through the angle post; Y^9 is the plunger in which is cut the recess or channel Y^{9x}, into which one end of the swivel bar Y^7 rests in its normal position. The pivot of the swivel bar is on the stud screw Y^{10}. On the top side of the swivel bar is the hole and bunch detector Y^8 made of thin spring steel, and fastened thereon by means of screws Y^{11} and Y^{12}. Y^{11} screws down tight and secures the detector in position. The offset in the feeder or detector Y^8 provides an arrangement whereby a vertical adjustment in relation to the work

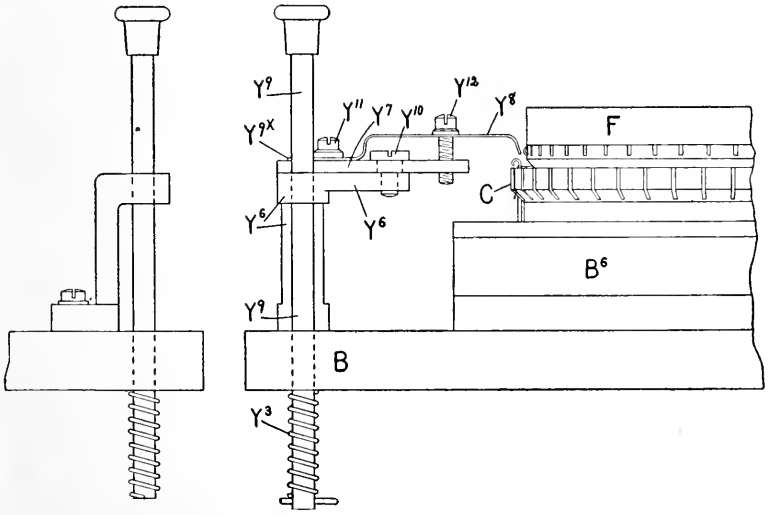


Fig. 52. Hole and Bunch Detector.

may be obtained by means of the adjusting screw Y^{12}. Normally, the detector rests with one end in the recess Y^{9x} and the other between the paths of the ends of the needles at the point where both sets of needles have just completed their stitch. If, however, a needle is misplaced, by reason of a bunch or hole, it will strike the inner end of the detector, and turning it on its pivot Y^{10}, throw the other end out of the recess in the plunger Y^9, releasing the plunger. This permits the spring Y^3 to force down the plunger to strike the trip Y^1 (Fig. 51) with sufficient force to release the belt shifter and stop the machine.

The Yarn Guide. Fig. 53 represents a yarn guide. A represents the shank in which is a slot to fasten it to the guide carrier C, which is fastened to carrier plate D, which, in turn, is fastened to the dial cap by means of screws through slots D. The part a^1 is known as the point, and part a^2, as the heel of the guide. This should be of such shape and so set that the point will prevent the open latches from closing until the stitch is safely enclosed in the hook, the point being bevelled so that a partly opened latch will be forced open without bending it. The heel also is usually bevelled, principally to avoid interfering with the hook of the dial needles.

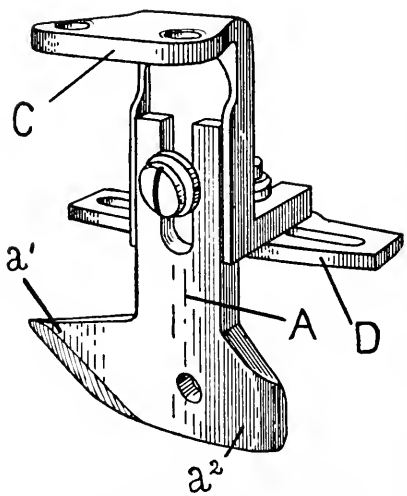


Fig. 53. Yarn Guide or Carrier.

The Needles. The cylinder needle, Fig. 54, is longer in the stem than the dial needle, being longer to admit of the various stitches made on it. In Fig. 54 are given the names of the parts of both cylinder and dial needles, though the names differ slightly with different makes, and the style or shape varies according to the position of the cams in the various other types of these machines.

Formation of Stitch. It is the function of the cams to actuate the needles in proper time to form the stitch. Their action and that of the attendant mechanism must be closely studied to acquire ability to run as tender yarn as possible, and obtain a maximum of perfect web with a minimum of needle breakage and other expenses. The formation of the loop should be thoroughly understood, and is described as follows: As the needles advance on the rise cams, the loops in the hooks open the latches, slipping over them into the throats, and the cylinder needles, on striking the stitch cams, take the thread from the thread guide. On drawing the needles back, the loops in the throats sliding under the latches, close them, thereby holding the thread in the hooks, and pass over them, clearing the needles and casting off onto the thread held in the hooks, in this way forming the new loops.

This method of stitch forming is shown in the diagrams I, II., III., and IV. in Figs. 55 and 55″; C representing a section of the cylinder and G a section of the dial, each with needles in about their relative

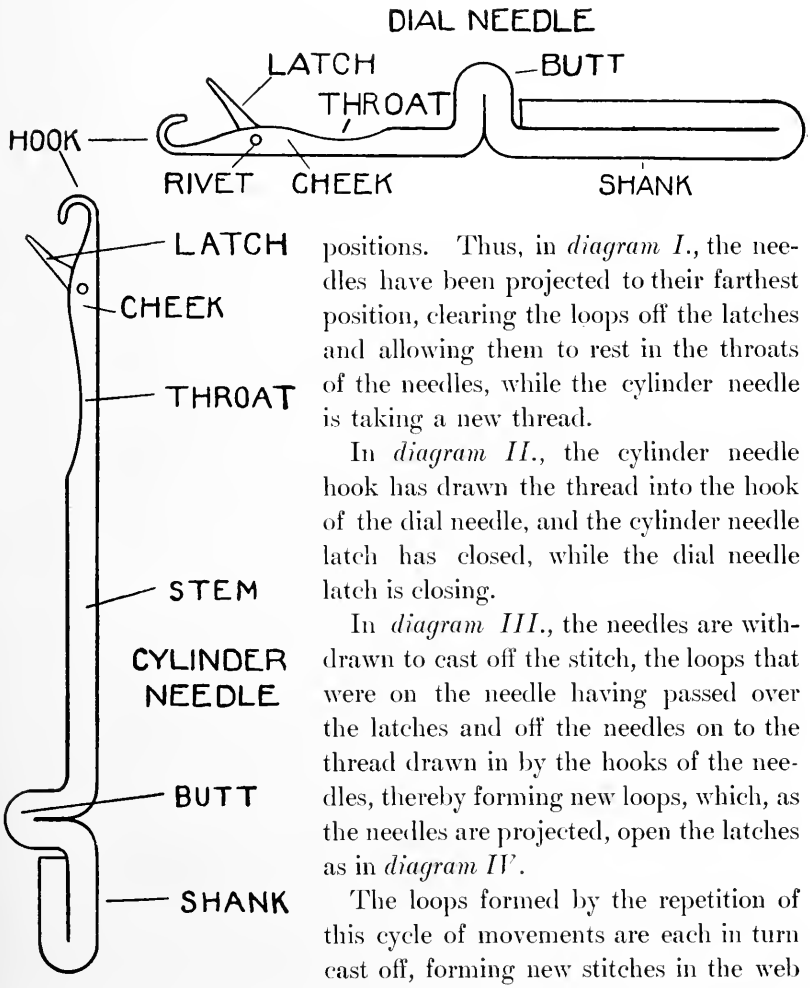


Fig. 54. Stafford and Holt Needles.

positions. Thus, in *diagram I.*, the needles have been projected to their farthest position, clearing the loops off the latches and allowing them to rest in the throats of the needles, while the cylinder needle is taking a new thread.

In *diagram II.*, the cylinder needle hook has drawn the thread into the hook of the dial needle, and the cylinder needle latch has closed, while the dial needle latch is closing.

In *diagram III.*, the needles are withdrawn to cast off the stitch, the loops that were on the needle having passed over the latches and off the needles on to the thread drawn in by the hooks of the needles, thereby forming new loops, which, as the needles are projected, open the latches as in *diagram IV.*

The loops formed by the repetition of this cycle of movements are each in turn cast off, forming new stitches in the web as long as the machine is in motion and yarn properly supplied to the needles.

Starting up the Machine. Before starting up the machine, turn it slowly by hand with the hand wheel, and see that the needles are working freely in the slots; that none of them are bent or broken,

or have stiff or defective latches; that the mesh of the needles is good, *i.e.*, with the dial needles coming out a trifle behind the center of the spaces between the cylinder needles; that the cylinder and dial are turning freely and true; that the two sets of cams are timed correctly (on most work so that the hook of the cylinder needle would just grasp the rivet in the dial needle latch, were it extended sufficiently); that there is sufficient room for the fabric to pass between dial and cylinder, and that the stitch cams of each feed are set to cast off the stitch perfectly.

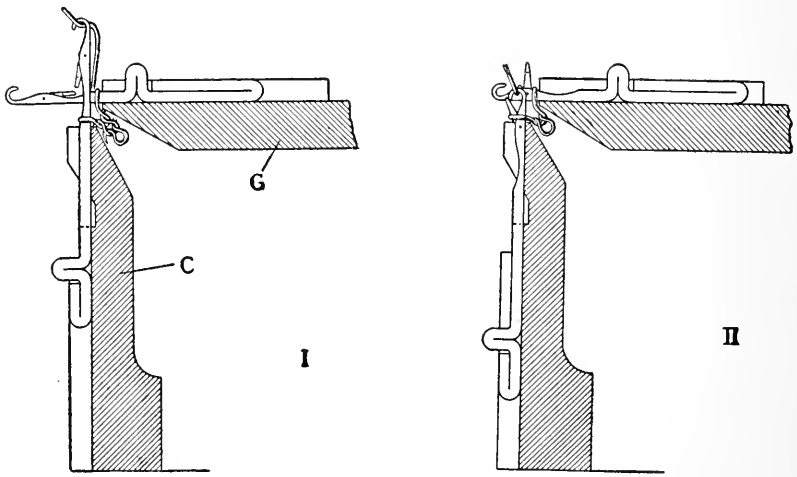


Fig. 55. Diagrams of Stitch Formation, I and II.

The *guides* should be carefully examined to see that they are perfectly smooth and set to deliver the yarn into the hooks of the needles, and yet not touch the needles. The heel should be set close to the point where the cylinder latches close, but must not interfere with them. The point must be close enough to the needles so that a cylinder needle latch, flying out horizontally, will not go behind it, and wedging in, become bent. The guide must be low enough so that the free end of the dial latch cannot clear it in its outward movement, and, flying up, lose the stitch. This trouble is also liable to occur if the two sets of cams are not properly timed.

The take-up should be examined to make sure that there is sufficient tension to take the goods from the needles nicely, and that there

is sufficient recoil in the contact of the rolls to allow the bunch where the fabric is started, or similar imperfections, to pass without clogging.

The machine may now be threaded up by placing the spools of yarn on their respective yarn hooks h^3 (Fig. 50), thence through holes in guide discs h^4 and h^5 to a hole in the top of the carrier. When this is completed for each thread, turn the machine so that the cylinder and dial drivers come opposite where the cylinder needles are resting on the fill-in cam, and insert the upper end of fabric between them. Hold it there with the left hand, and with a hook or needle held in the right, catch hold of the fabric as near the end as possible, and draw it up through the space between the cylinder and the dial, slipping it

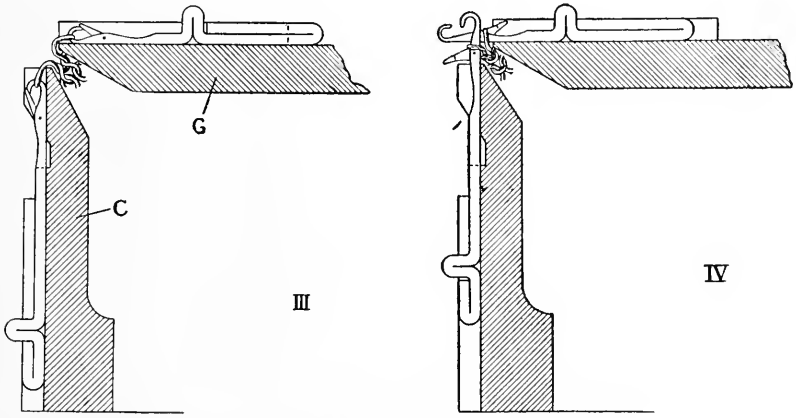
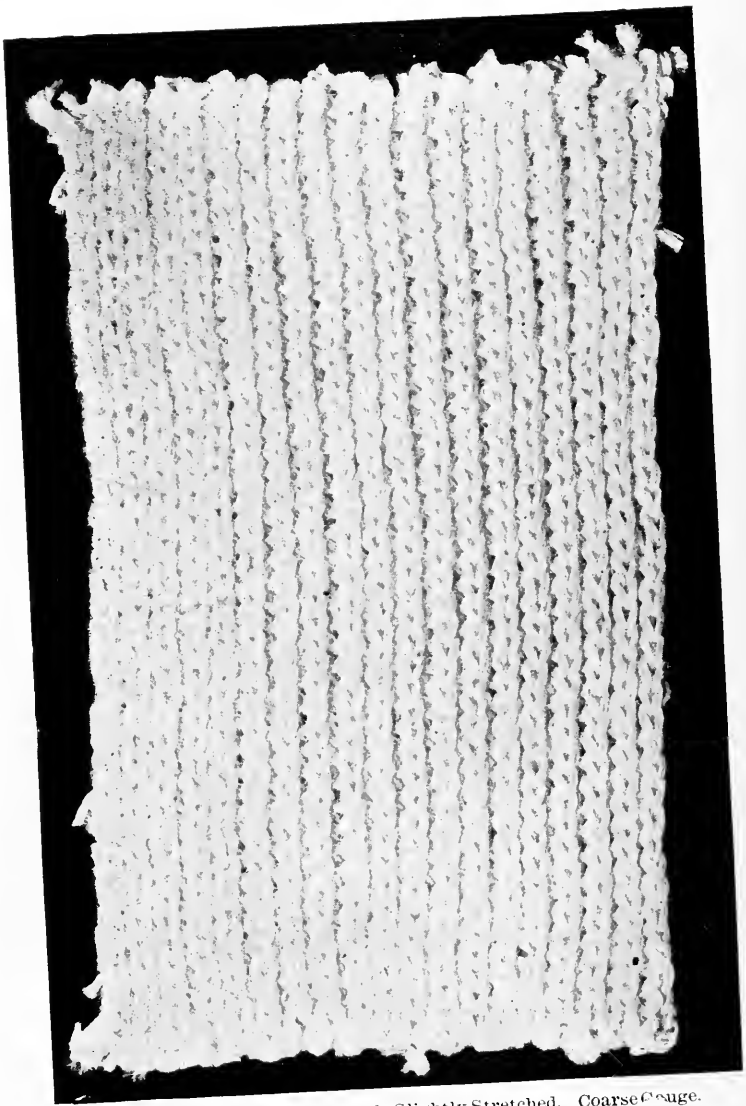


Fig. 55A. Diagrams of Stitch Formation, III. and IV.

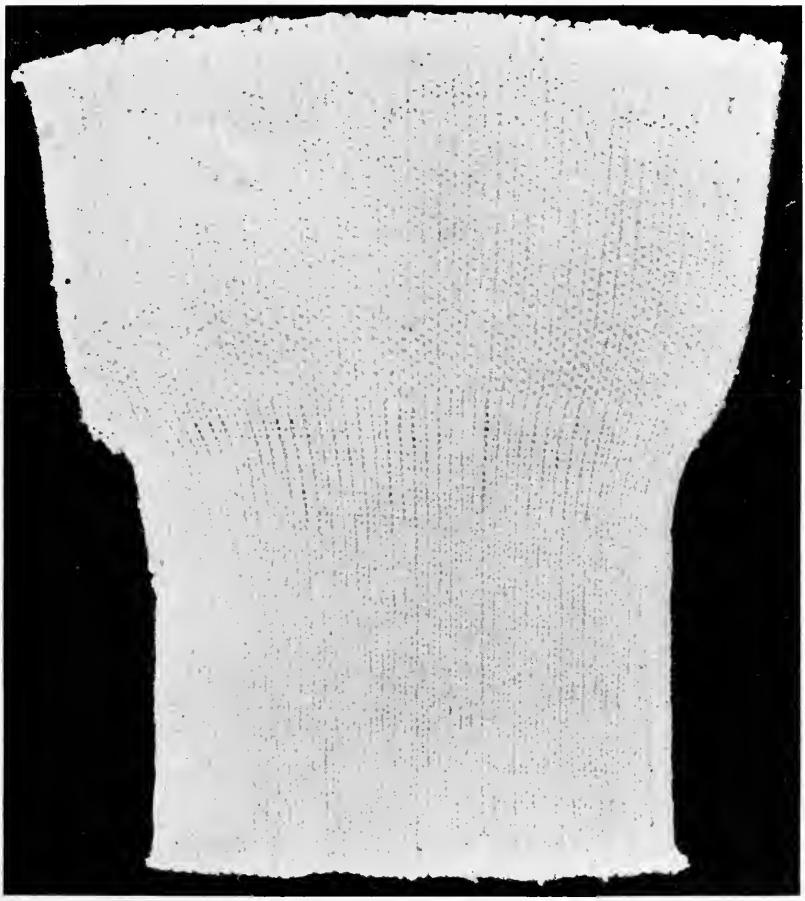
over and on to the hooks of the cylinder needles. Turning the machine slowly and at intervals, by the hand wheel, draw the end of the fabric onto all the needles as they come into position, until the needles with the fabric hooked on come to a yarn guide, then pass the end of the yarn through the hole in the yarn guide and into the hooks of the needles.

The loops are formed at this point, and knitting begins as the operation of turning and hooking on the fabric is continued. Be careful to start each thread as soon as the fabric hooked in the needles reaches a yarn guide, and to draw the fabric through the second pair of drivers as they are reached; continue hooking on and threading up until the fabric is hooked on the needles all around the machine.



One-and-One Plain Ribbed Goods Slightly Stretched. Coarse Gauge.

Now introduce the other end of the fabric between the take-up rolls, and put on sufficient tension to hold the fabric on the needles and prevent a pull-off.



Cuff of Ladies' Vest.

When turning the machine during the hooking-up process, use the left hand to exert a tension on the fabric similar to that which the take-up exerts when in action. This "run on" portion is cast off by the needles with more or less difficulty, according to how closely, loop for loop, the fabric has been picked on. The machine should be

turned slowly until all latches are carefully opened, dropped stitches picked up, and damaged needles replaced.

When this has been accomplished, look over the adjustment of the yarn guides; the adjustment and timing of cams, and the adjustment of take-up, as at this stage of operation adjustments can be more carefully made. Then start the machine by power, watching carefully to see that all the parts are doing their work properly.

On an automatic machine, it is perhaps best to start on the plain stitch, then start the chain, and when it changes to tuck stitch, stop the machine, looking over each dial tuck feed carefully to see that the cams are advancing the needles far enough to catch the stitches, but not far enough to allow any to slip over the latch and thus out of the hook. Then proceed to even the stitch, which is usually done when the machine is on the plain stitch, by carefully looking over the dial cams and setting them to draw the needles into the dial the same

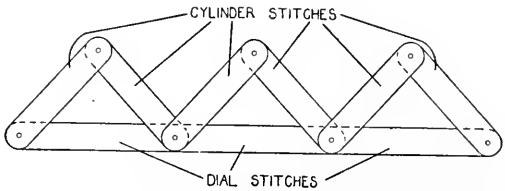


Fig. 56. Link Chain, Simile of Tuck Stitch.

distance or as nearly as possible; then mark each thread at an equal distance from its respective guide, and turn the machine by hand. Note which threads arrive at the guide first; make the required changes of cylinder stitch cams, so that all the marks will arrive at the guide at the *same time,* which will sometimes require several changes. If using white yarn, it can readily be marked by placing one end of a scale at the hole in the guide, and grasping the yarn at the other end of the scale, slightly twisting it between the thumb and forefinger of the other hand, somewhat soiled with the oil oozing from some bearing. If dark yarn, use powdered chalk for marking. Care should be used that the length of yarn measured off should be as long as convenient, and the length accurate at the same tension.

To Shorten or Lengthen the Stitch. A small set screw B^7, Figs. 41 and 42, bears against the stud which holds the stitch cam in the cam ring. By means of this set screw, the stitch cam may be

adjusted up or down. The stitch cam B^3 is riveted to a spline, for which there is a key seat in the cam ring. This serves as a guide for the cam. Turn the set screw B^7 *in* to slacken or lengthen the stitch,

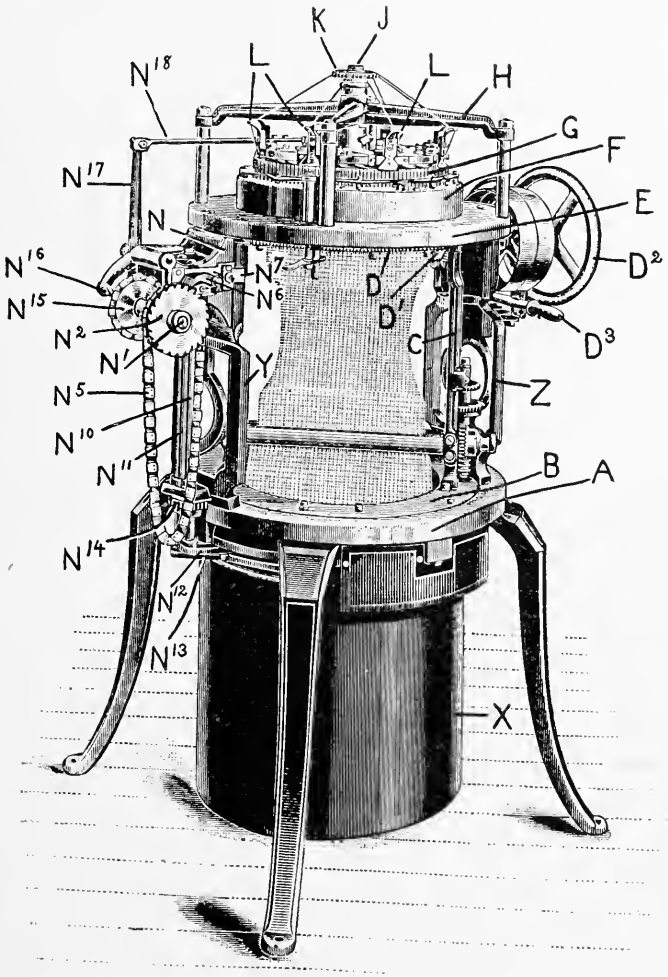


Fig. 57. McMichael and Wildman Machine. Revolving Needle Cylinder.

and turn it *out* to tighten or shorten. The dial cam is adjusted in a similar manner, by means of the set screw F^{10}, shown in Fig. 45. Turn the set screw in to lengthen, and out to shorten or tighten the stitch.

The stitch is also adjusted by raising or lowering the dial and cap by means of the dial arch nut G^2. (Fig. 39.) Raising the dial slackens or lengthens the stitch, and lowering the dial tightens or shortens the stitch. This is similar in effect with that obtained by adjusting the cylinder cam B^3.

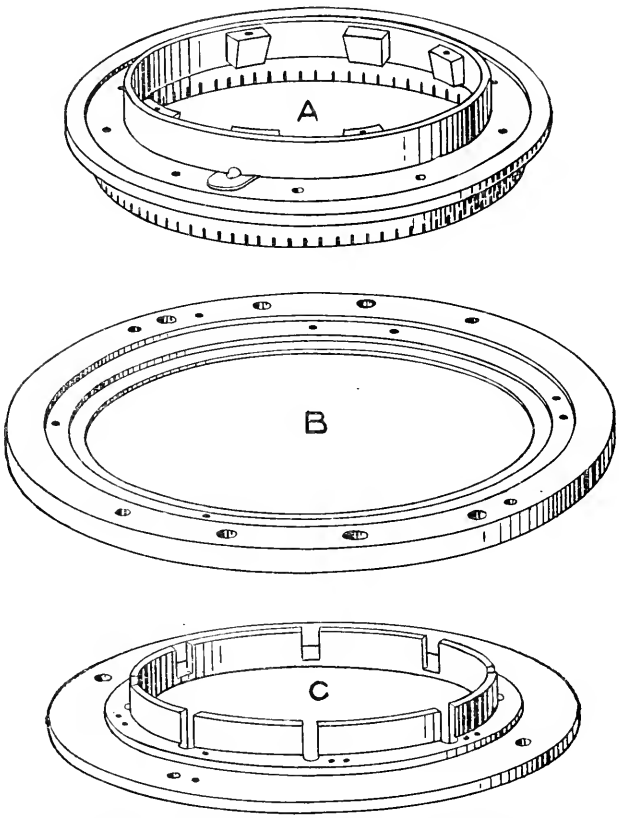


Fig. 58. A, Gear Ring. B, Head Ring. C, Cam Ring.

To Remove a Section of Cylinder or Dial. The upper part of the cam ring, or what is generally termed the section ring, Figs. 39 and 41, and also the cylinder gib, is divided into as many sections as there are feeds on the machine, and each section is held in place by two screws, B^{12}, shown in Figs. 41 and 42. A cylinder section may be removed by loosening these screws. On the dial cap,

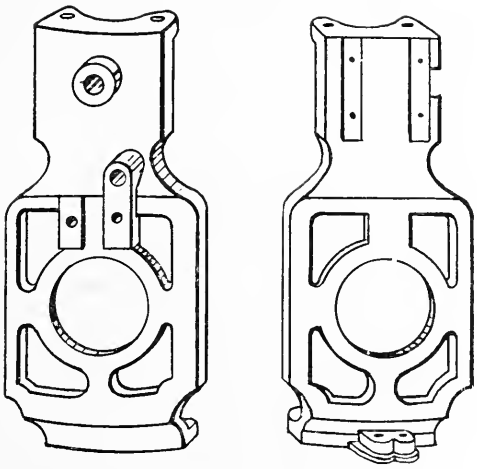


Fig. 59. Housing Plates.

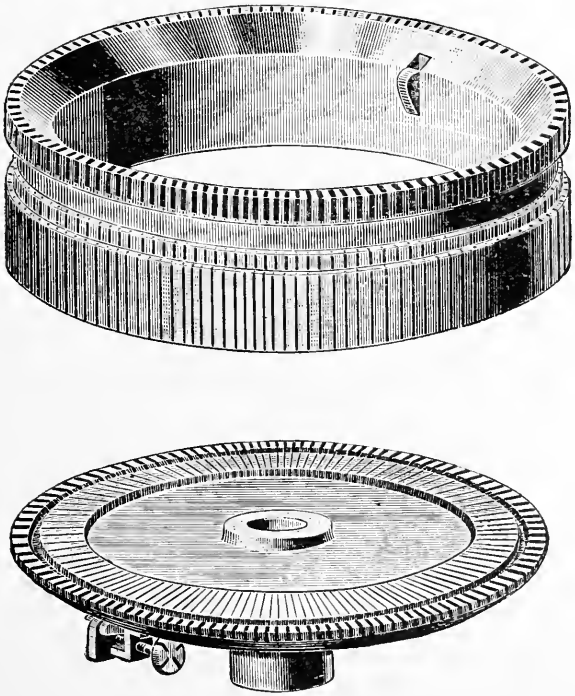


Fig. 60. Dial and Cylinder.

the top ring can be divided as indicated by the three broken lines in Fig. 45, and each section will be held by two screws, the bottom of which also show in Fig. 45.

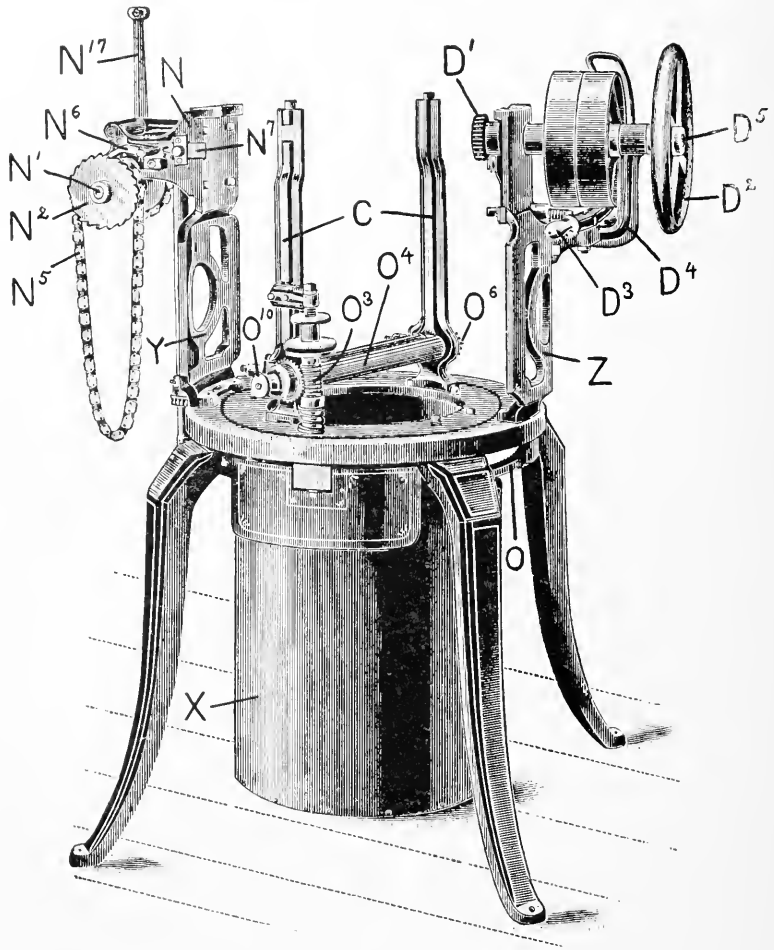


Fig. 61. Frame and Take-up.

Loading up the Needles. If anything goes wrong when the machine is running, the yarn begins to load up near the top of the needles. If a hook or a latch bends, or a butt cuts off, or lumps or other imperfections occur on the needles, it can, as a rule, be detected almost instantly by the load on the needle, which causes the stop

motion to act immediately. About the only imperfection that does not cause a load is an occasional dropped stitch or the head of a needle cut clean off. As these have no stitch on to hold them in place, they usually jump up and are caught by the stop motion. If the butt of the needle is entirely broken, the needle remains stationary and will not throw off its loop, but the needles on either side will accumulate yarn, and if not discovered, will soon cause two or more needles to be broken at either the hook or the latch. Twits in the yarn coming into needles running at high speed, break, causing the needles to jump, and, falling back, become wedged under the cams.

A Tuck Stitch makes a wider web, because more yarn is employed in making the stitch. The tuck stitch and plain stitch may be

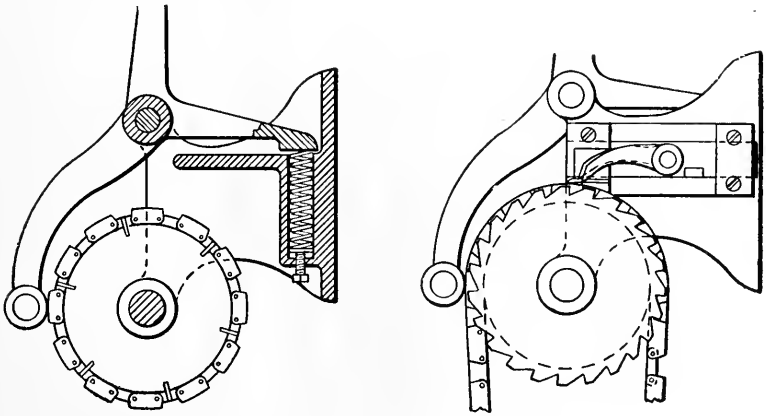


Fig. 62, Detail of Cam Controlling Mechanism.

likened to link chains, the plain stitch resembling the chains drawn out parallel or straight. The tuck is formed like fastening two links of one chain into each link of the other, as per Fig. 56. Unlike the chain, the yarn is not rigid, and seems not only to draw up and thicken the fabric, but also, because of the nature of the stitch formation, to spread it out wider.

To Make a Loose Course. A loose course is a single stitch of more than normal length, extending completely around the web or fabric. It is employed at certain points in the web or fabric where the rib fabric is looped on to another fabric, as a cuff or border on a balbriggan shirt, or rib top on a stocking or sock, and is usually made

by depressing one of the cylinder stitch cams for exactly one revolution of the machine.

To Make a Welt. A welt is a hem in the fabric and is used for a finish similar to a selvedge edge that will not ravel. It is made

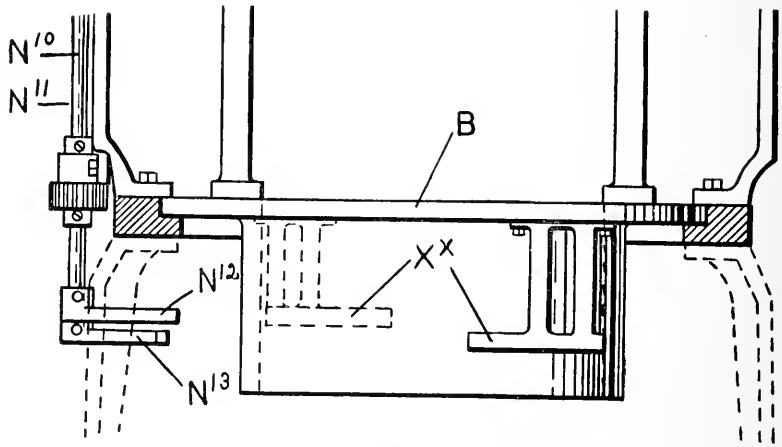


Fig. 63. Cam System for Actuating Automatic Mechanism.

by preventing one set of needles (usually the dial needles) from taking the yarn or casting off their loops for a certain number of courses, while the other set continues to knit a flat fabric. When the

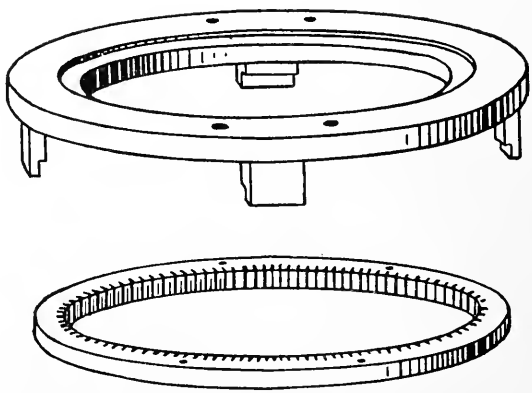


Fig. 64. Base and Gear.

first set is thrown into action, having retained the stitch from where the other set began to make single fabric, this loop is cast over with

the last loop made by the cylinder needles, joining both ends of the single fabric and making a perfect hem.

A welt is usually limited to *four or six courses,* unless special provision is made to hold down the fabric made by the single set of needles, as the stitch on the dial needle prevents the take-up from exerting its normal tension, while the single fabric is being knit. The more courses, the more bulky will the welt become, making it pass with difficulty between the cylinder and dial, unless provision is especially made to facilitate it.

Some of the variations in the style of this type of machine (Revolving Needle Cylinder) are herewith explained.

The frame illustrated in Fig. 57 (McMichael & Wildman Machine (has the same general outlines common to all circular rib

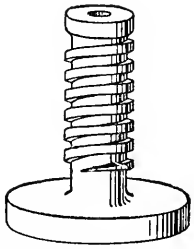


Fig. 65. Worm.

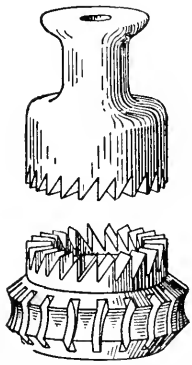


Fig. 66. Clutch and Worm Gear.

knitting machines. Four legs support the annular base frame A, which is machined to guide the take-up plate B, and connected by the take-up standards C C to the rotating bevel gear ring D (See A, in Fig. 58). This is seated in the stationary *bedplate* or head ring E (B in Fig. 58), supporting the stationary cam ring F (C in Fig. 58), and in this cam ring the vertical needle cylinder G is mounted in condition to rotate. On the base A is mounted the housing plates Y and Z (Fig. 59), which support the bedplate E. From the cross-tree H, supported on the bed ring E, depends the rotary needle dial I on the center stud J, on which it rotates, held up in position by a collar fastened to the lower end of the stud. Above the needle dial

(See Fig. 60) a stationary cam dial is suspended, fixed to the center stud by set screws. These dials may be raised or lowered, when adjusting the plane of the horizontal or dial needles in relation to the plane of the vertical needles in the cylinder by turning the hand wheel

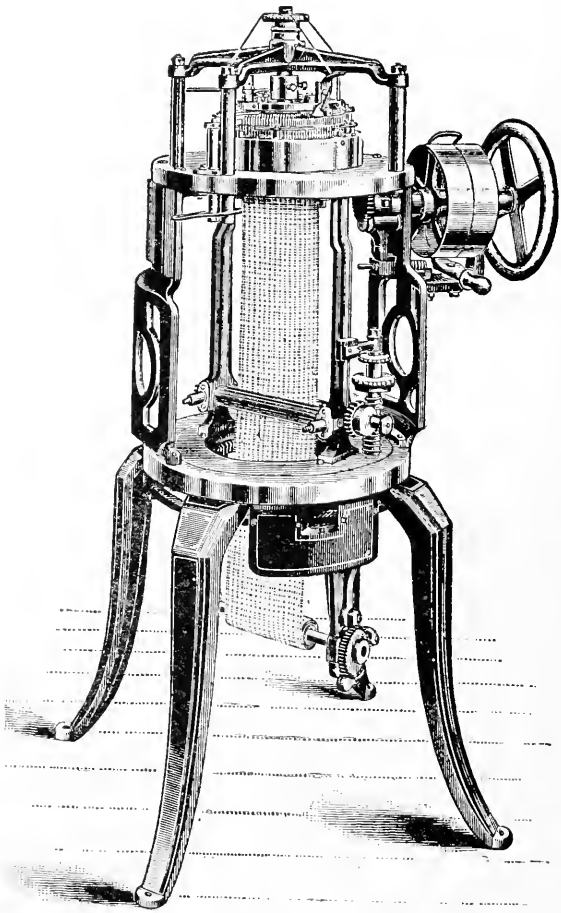
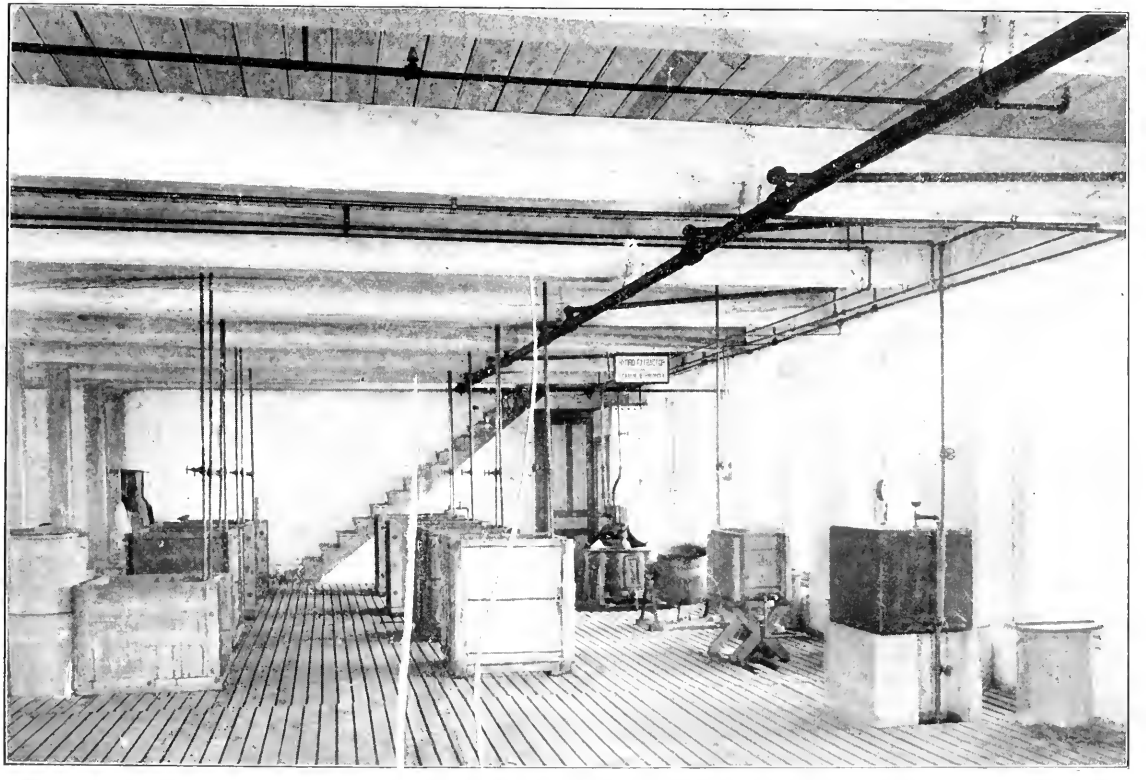


Fig. 67. Plain Machine with Fabric Roll in Place of Can.

K. The thread guides L are fixed to the stationary cam dial in a manner to properly present the thread to the needles at points where the dial needles are operated by the cams.



VIEW IN TEXTILE DEPARTMENT OF CLEMSON COLLEGE SHOWING CORNER OF DYEING ROOM

The bevel gear ring D receives its motion from the spur gear D^1, which is fixed to the driving shaft D^5 (See Fig. 61) and on which are tight and loose pulleys. The shaft D^5 is mounted at the inside end in a bearing in the right housing plate, and at the outer end in a bearing in the bracket D^4 fixed to the same housing. The power is transmitted by a belt, which may be shipped from one pulley to the other by means of the shipper D^3. The hand wheel D^2 is fixed to the driving shaft for use when the needle cylinder is required to be turned slowly for replacing needles, repairing, cleaning, etc.

The Chain Actuating Mechanism. This mechanism on the left of the frame (See Fig. 57) is for the purpose of automatically

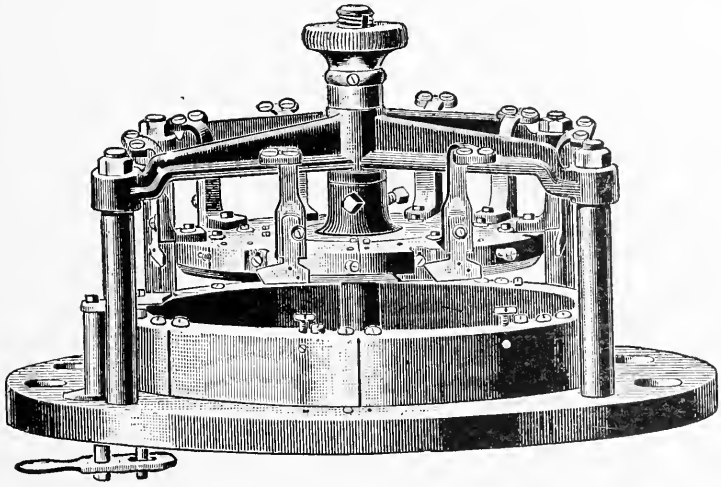


Fig. 68. Body Machine Head.

operating the movable cams of the cam dial plates, to move the needles farther out, or to draw them in, to narrow or widen the fabric for shaped goods. In the bracket N, fixed to the left housing, is a shaft N^1 on one end of which is fixed a ratchet wheel N^2 and back of this wheel is a sprocket wheel, or pattern chain wheel, secured to another ratchet wheel, both free to revolve on the shaft. The sprocket carries the pattern chain N^5 and receives its motion by means of the pawl N^6 connected to the slide N^7. A larger view of this is given at Fig. 62. This slide is moved back and forth in its guide by the levers fixed on the upper ends of the upright shafts N^{10}, N^{11} (Fig. 63). At the lower

ends of these shafts are secured arms N^{12} and N^{13}, which are acted upon by the cams X, secured to the rotating take-up plate B. These upright shafts are geared together at N^{14} (Fig. 57), so that when one is acted upon by its cam, the other turns in an opposite direction, and *vice versa;* this short reciprocating motion imparts to the pawl, through its connections, the required movement to actuate the ratchet wheel and move the shaft N'.

On the left end of the shaft is fixed a toothed disc N^{15} on the periphery of which rides a roll N^{16}, secured to the lower arm of the elbow lever N^{17} (See also Fig. 62). By this means, motion is imparted through the connecting rod N^{18}, to the pivoted dial cam, when the pattern chain permits the pawl to engage the ratchet wheel which is fixed on the opposite end of the shaft.

Operation. As the needles are carried round by the rotary needle dial and cylinder, they are operated by the respective cams to take the thread and form the fabric in the usual manner. The character of the fabric produced is governed by the pattern chain, which is carried on the sprocket wheel, operated in the manner described. The operation of the needles continues in a uniform manner as in plain knitting, or otherwise, until a notch in the pattern chain comes under the pawl, when the latter immediately operates the ratchet and shaft with its wheels, and in the manner described, moves the cams, and thus draws the needles in or out, as the case may be, and correspondingly changes the character of the fabric produced. When the cams have been so changed, the needles continue to operate in the same manner until the next notch in the pattern chain passes under the pawl, when they are moved back, and correspondingly change the extent of the movement of the needles and the character of the fabric produced.

Worm Gear Take-up. The take-up or tension rolls are driven by a worm gear arrangement. Fixed to the projection on the under side of the annular base is a stationary internal gear O (Fig. 61). The take-up mechanism is fixed on the rotating take-up plate B and as it turns, the pinion gear fixed to the lower end of the worm shaft and meshing into the stationary internal gear (Parts shown in Fig. 64), causes the worm 0^3, Fig. 61 (also shown at Fig. 65), to revolve and impart motion to the fluted take-up rolls 0^4 and 0^5. These are journaled in the take-up standards C C and the knitted fabric passing

between them is held firmly enough to maintain the required tension on the fabric, between the take-up rolls and the needles. The driven

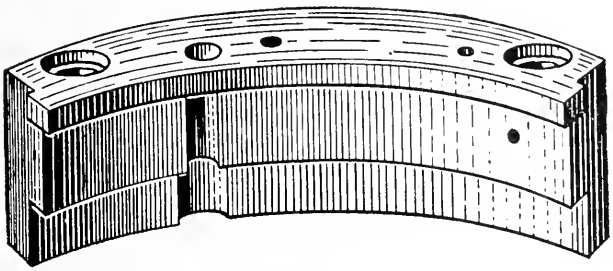


Fig. 69. Cam Ring Section.

take-up roll 0^5 is geared at 0^6 to the driver roll 0^4 at the opposite end from the worm gear, Fig. 66, and is journaled at each end in sliding blocks, guides being provided for that purpose in the take-up stand-

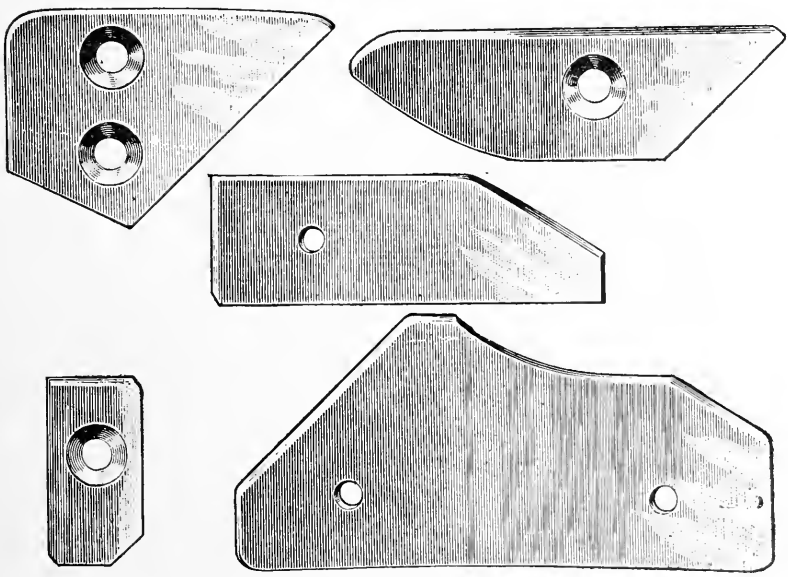


Fig. 70. Cylinder Cams. Full Size.

ards. These blocks and guides are so arranged that a yielding pressure is maintained on the frame by means of coil springs confined in sleeves fixed on the side of the take-up standards and against each block.

The worm gear is loose on the driving roll and is provided with a clutch, Fig. 66, feathered on the driving roll in such a manner that when the clutch is pulled away and disconnected from the worm gear, the rolls are at rest, leaving the worm gear free to revolve on the shaft. The worm shaft pinion gears vary in size according to size or diameter of the frame. Underneath the frame is can X, which receives the fabric during the knitting, and which is attached to and revolves with

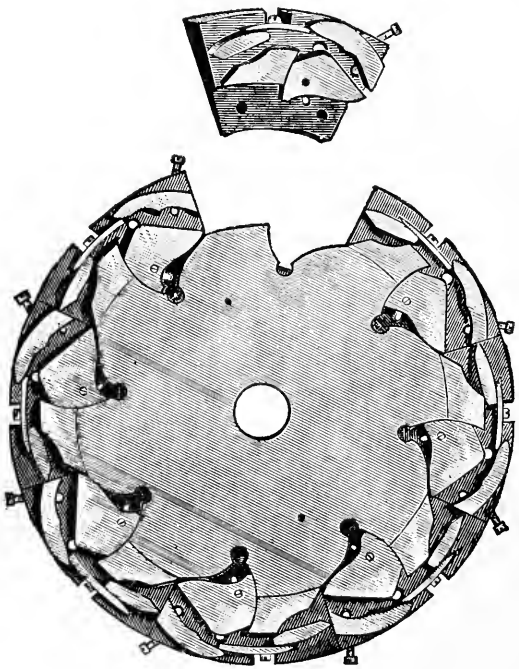


Fig. 71. Cam Dial with Section Removed.

the take-up plate. A fabric roll is often used in place of the can, and the fabric rolled up as shown in Fig. 67.

Head and Cam Ring and Cam Dial Plate. Fig 68 represents a plain body machine head, without the needle cylinder and needle dial, and more clearly represents the position of the sectional cam ring, the cam dial cap, the cross-bar, the thread guides and the manner of holding and adjusting the cam dial cap in position. These parts are all stationary. The sectional cam ring consists of an arrangement of the cam ring in a number of sections, corresponding to

the number of feeds on the machine, so that each section may be removed, exposing all the needles covered by that section when necessary for repairs, cleaning, etc. Fig. 69 shows a section of the cam ring, inside view, and Fig. 70 shows the cylinder cams, full size, those attached to the cam ring and actuating the cylinder needles.

Fig. 71 represents the under side of the sectional cam dial and a section removed. The sectional dial cap is divided in a similar way

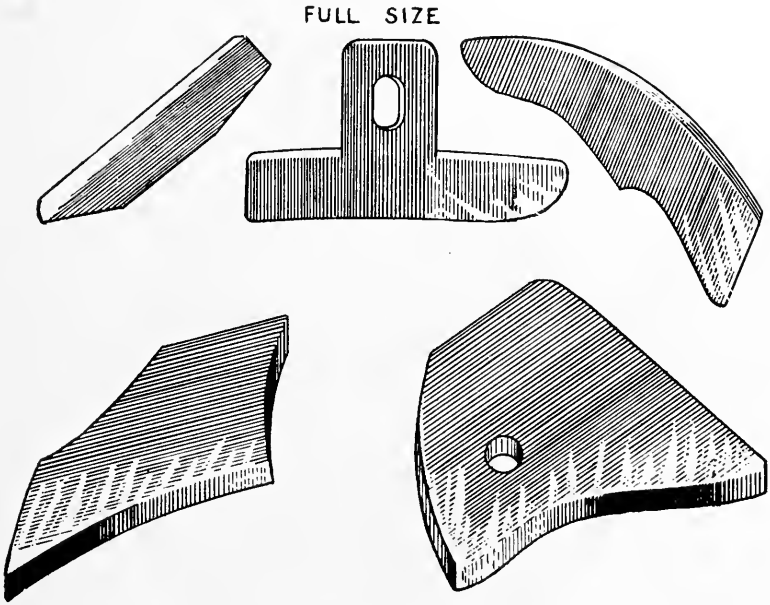


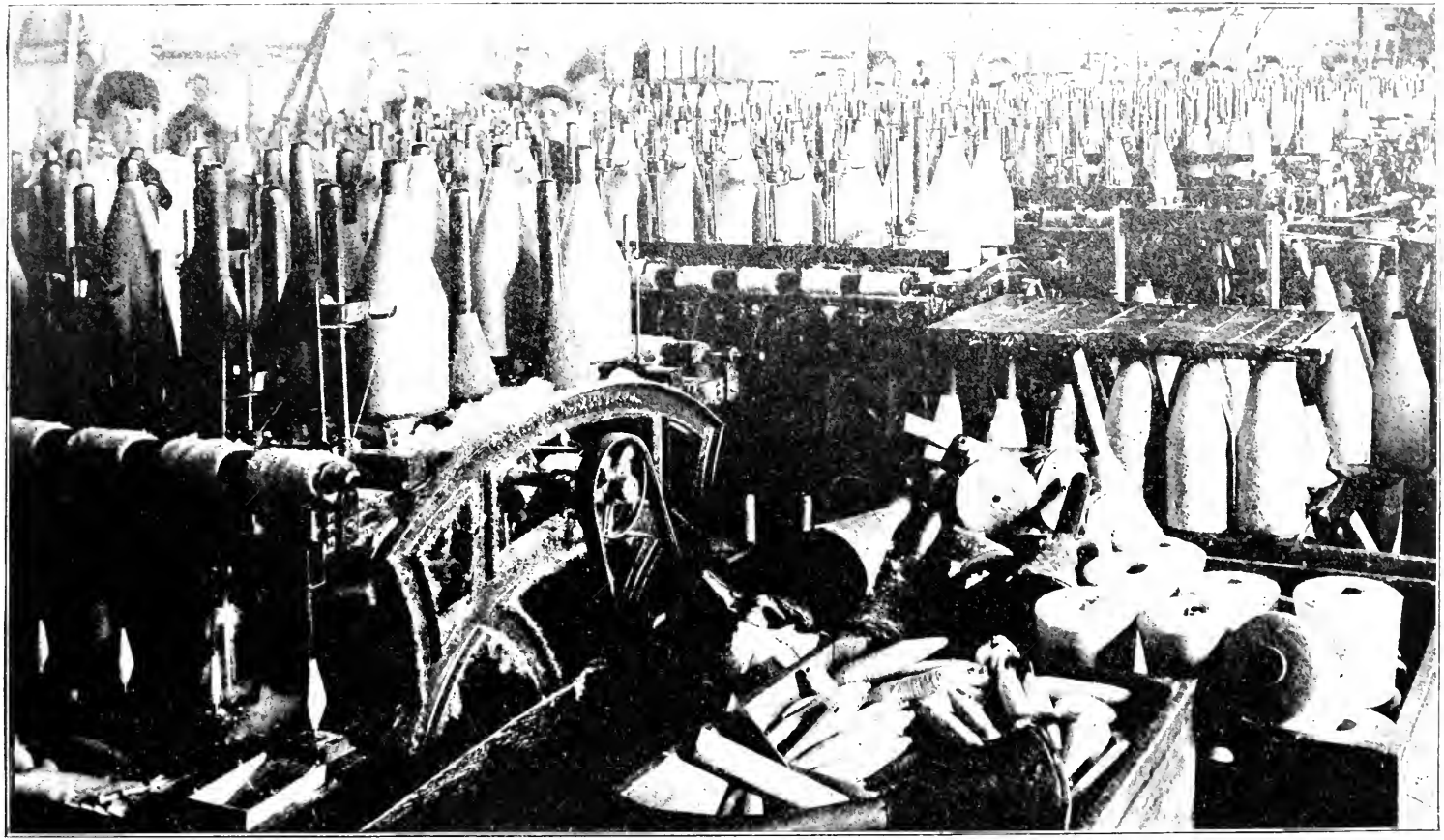
Fig. 72. Dial Cap Cams.

to the cam ring, each section containing in addition, the dial cams of the feed for actuating the dial needles, and the yarn carriers, or guides for delivering the yarn to the needles. Any or all of the sections may be removed, without running the fabric off the needles, by loosening the take-up.

The dial cap cams (Fig. 72) are disposed in positions to cause the needles to be reciprocated in a proper manner to co-operate with the cylinder needles to form the stitches, the cylinder needles first taking the yarn, after which the radial or dial needles operate with it to form the stitches. The "Automatic" cam dial is provided with movable cams so pivoted that they act on the butts of the dial needles and

move them in or out as the character of the knitting may require. The needle dial is provided with lugs (See Fig. 60) which are engaged by lugs on the needle cylinder and serve to transmit motion from the cylinder to the dial.

Other variations in latch needle circular machines may be noted in the mechanisms for taking up and rolling up the fabric and manner of applying or creating the tension on the fabric as it is being knitted; in the shape of both the stationary and movable cams to act on the heels of the needles to move them in or out, as the character of the knitting may require, together with the consequent changes in the form and location of the butts of the needles; in the stop motion mechanism; in the manner of actuating the movable cams, and in other mechanisms and the consequent changes in construction, so that the yarn is fed by the guides to the needles carried by the rotary needle cylinder and dial, and actuated by their respective cams, to take the thread and form the fabric in the customary manner.



SECTION OF KNITTING ROOM SHOWING WINDING AND KNITTING

KNITTING.

PART III.

STATIONARY NEEDLE CYLINDER MACHINES.

A type of Circular Latch Needle Machine, which is somewhat different from those taken up in Part II, is the Stationary Needle Cylinder in which the *cam ring*, *cam dial plate*, *bobbin rack*, and *cross-bar* revolve. As the needle cylinder and the cloth are stationary, the take-up is fixed to the frame, but the feeds and the bobbins as well as the cross-bar must revolve. These parts, with the *cam ring* and *dial plate*, compose the head.

Fig 73, the Scott and Williams Circular Latch Needle Automatic Machine, is a representative of the above type of machine with a revolving head. The most notable difference that may be observed in this illustration is the manner of applying the take-up to the frame, as the cloth is not revolved.

The Cam Ring, carrying the cylinder needle actuating cams, revolves around the stationary needle cylinder and thereby acts on the butts of the needles, moving them up and down with the required amount of travel to effect the formation of the stitch, instead of the needle cylinder carrying the needles around to the stationary cams to be acted upon.

The cam ring contains all the cams for operating the needles in the needle cylinder, and also the main stitch cams which control the yarn. The projection, Fig. 74, and the section as illustrated in Fig. 75, show the disposition of the cams in this machine, and their relation to each other.

The Ring Cams, or Cylinder Cams. The *cover cam* A, Fig. 76, is merely to guard the needles and prevent them from "flirting," or jumping while the machine is running. It has no function to perform in making the stitch. The *landing or clearing cam* B lands the needles to a tuck point, so that all the latches are safely opened before the yarn guide covers the needles to feed them new yarn. The highest

point of the cam is the clearing point for placing the old loop under the latch in order that it may be cast off the needle over the new yarn, thus making a new loop.

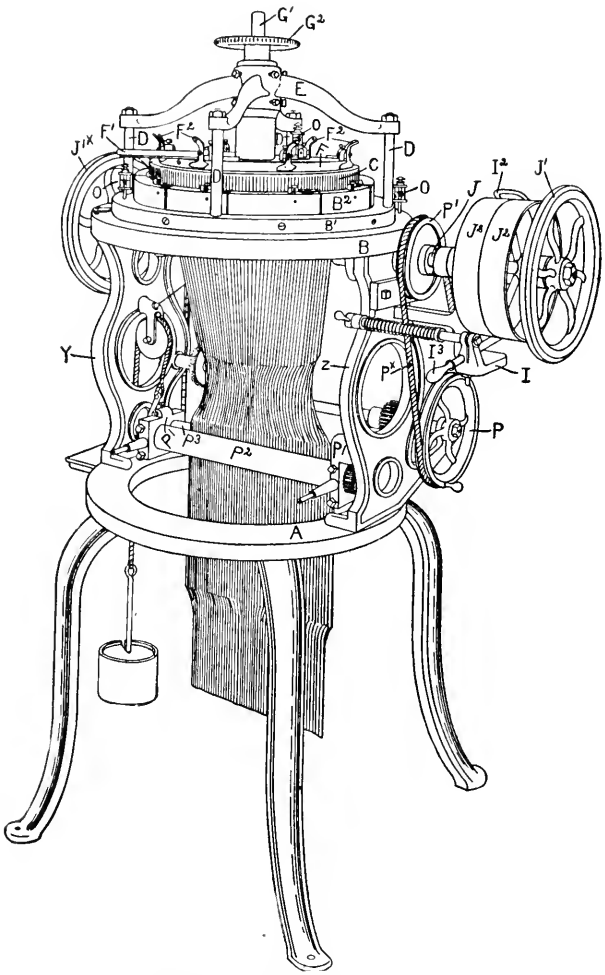


Fig. 73. Scott & Williams Machine
Stationary Needle Cylinder.

The *stitch cam* C controls and regulates the length of the stitch for both sets of needles. In Swiss knitting, the top and the bottom cam draw their yarn separately, which makes a much more elastic

fabric. The foreign machine manufacturers build their rib machines on this principle at the sacrifice of speed.

The *rest cam* D returns all the needles to one common level after the stitch has been formed, the main object being to even the length

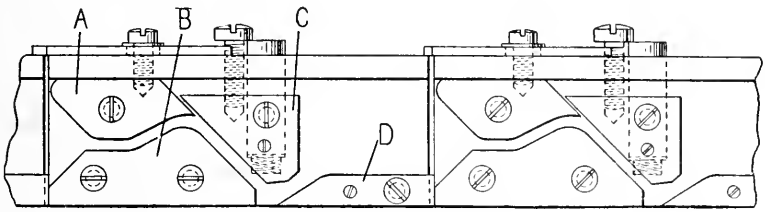


Fig. 74. Projection of Cam Ring.

of the stitches. Without this cam, a tight or stiff needle would make a slack line in the fabric.

The *land or tuck cam* B lands the needles to a tuck so that all the latches are safely opened before the guide covers the needles for pla-

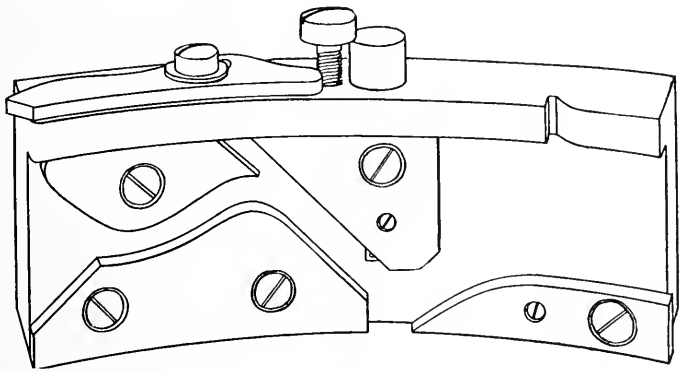


Fig. 75. Cam Ring Section.

cing a new stitch on them; while the *landing or clearing cam* C has the same functions to perform in the dial as the B cam in the ring.

The *rest cam* D performs the same function as does the D cam in the ring; the draw-in cam casts off the old stitch placed on the top needles by the cylinder needles; this cam also acts as a dividing cam for the top loops; it has nothing to do with the stiffness of the fabric. The *cover cam* F does the same work in the dial as cam A in the ring.

The Cap or Dial Plate (Fig. 77) contains all the cams for operating the needles in the dial, and also the movable clearing cams for making plain and tuck stitches for producing plain and royal fabrics used in making ladies' shaped vests and union suits.

The Cap Cams or Dial Cams (Fig. 78). The slide cam A is used for making regular royal fabric, or for making fancy stitches in lace work. When used in connection with a movable cam in the ring of two or more feeds, a full cardigan stitch can be formed.

STARTING UP AND ADJUSTING STATIONARY NEEDLE CYLINDER MACHINES.

The following instructions apply in most part to revolving head machines, though more particularly to the Scott & Williams frame, which is so commonly used in this class; and include directions for adjusting a frame that has never been run, or has been out of commission for some time.

Clean off the machine thoroughly and see that the working parts are well oiled, taking care to oil the cylinder and dial only slightly with a light, stainless oil. Belts of nearly the full width of the receiving pulley should be used, and run at an angle that will not interfere with the belt-shifting-fork. Fill both cylinder and dial with the necessary needles, after having removed all those broken, bent, or otherwise disabled, and see that the latches work freely and cover the hook perfectly.

Adjust all the *dial draw-in cams* to draw the needles about $\frac{1}{32}$ of an inch inside the diameter of the dial.

Adjust all the *cylinder draw-down* cams to draw the needles about $\frac{1}{16}$ of an inch below the top of the cylinder.

Adjust the *cap* circumferentially until the hooks of the cylinder needles meet the rivet of the dial needles.

Set the *height of the dial* so that a needle will pass freely between the edges of the cylinder and dial, or leave a space between the cylinder and dial wide enough so that the old fabric to be used in setting up the machine will pass freely between the cylinder and dial at the place where it will be joined to the new fabric. This adjustment must be made by the threaded wheel and center spindle at the top of the machine.

Fit all the yarn guides to the machine. The yarn guides, Fig. 79, should not touch the needles at any time, but should be set $\frac{1}{16}$ of

an inch above the dial needle and about $\frac{1}{32}$ of an inch away from the cylinder needles; the circumferential position of the guides should be such as to allow the cylinder needle latches to close without striking the guides; the leading end of the guides should then cover both the cylinder and dial needle latches just before the latch passes through the fabric. This prevents the latches from closing after leaving the control of the fabric on the old loops.

To Press-Up a Machine or Replace a Press-Off. If there is no fabric on the machine, procure a circular piece of cloth, knitted if possible, of about the same diameter as the needle cylinder. Press up the machine by placing the fabric between the cylinder and the dial dogs. To do this, insert a needle down through the space between the cylinder and dial, and with the hook of the needle, catch a narrow,

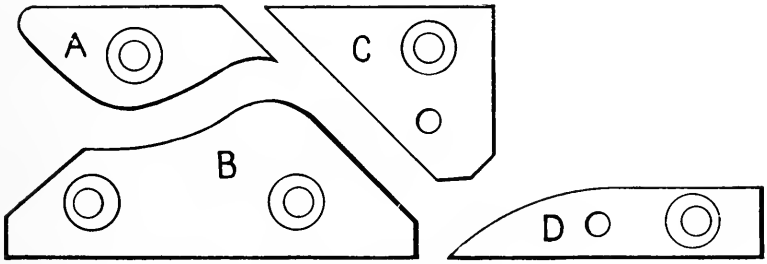


Fig. 76. Cylinder Cams.

yet firm, hold on the edge of the fabric which is to be placed on the needles, and pull it up until it can be grasped by the fingers of the right hand; put the left hand underneath and up through the hole in the needle cylinder, grasp the fabric, and by means of a sawing motion, force the fabric between one of the sets of dogs which prevent the dial from turning.

The machine should be turned at this time so that one of the resting points for the cylinder needles will come where the work is inserted between the cylinder and dial. At such points the cylinder needles are partially elevated, so that the edge of the fabric may be quite easily pulled on to the needles. Too wide an edge would make it difficult to operate the machine, and too narrow a bite would allow the cloth to be easily pulled off the needles. About $\frac{1}{8}$ of an inch from

the needles to the edge of the fabric, or a trifle less, will be found sufficient in most cases.

After the fabric has been pressed on to several needles at this point, it is well to go around to the other side of the machine and pull it up between the other set of dogs, and place it on about the same number of needles, going through the same operations as before. Then press the cloth on to a few needles between the feeds, and turn

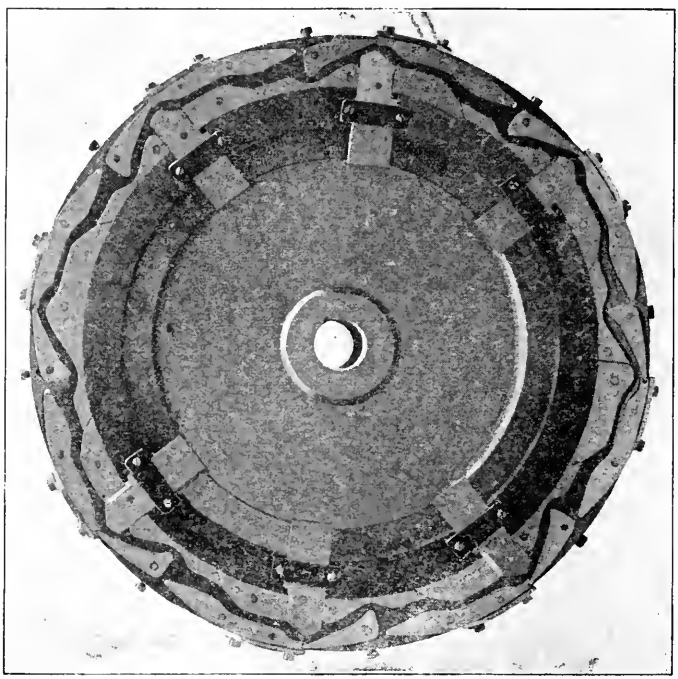


Fig. 77. Cap or Dial Plate.

the machine slightly, repeating this same process until the fabric has passed under the yarn guides.

Thread the guides and hold the work down by hand, catching hold of the cloth under the head with the left hand, while turning the machine slightly to bring other groups of needles into accessible positions to place the rest of the fabric on the empty needles. Repeat this operation until all the needles have loops placed upon them, then place the other end of the fabric between the take-up rolls, and adjust them to have a fairly taut tension on the fabric. Too much tension

should not be applied until the rough edge of the run-on portion of the cloth is off the needles.

Now, if all the yarn guides are properly threaded, the machine may be slowly turned by hand a short distance at a time, meanwhile opening all the latches that have not been opened by the pressing-up, and picking up all the dropped stitches and placing them on their

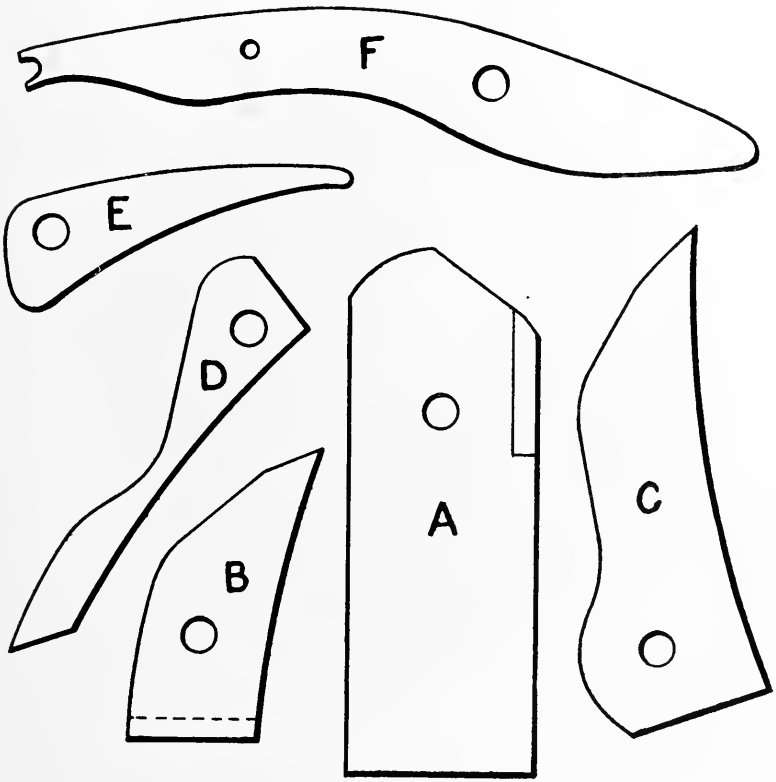


Fig. 78. Dial Cams.

proper needles. At this time, the cylinder and dial may be *thoroughly oiled.* Oiling was done but slightly before placing the fabric on the machine, as excessive oiling before that operation makes a machine hard to press up, the oil affecting the yarn and fabric to such an extent that it is almost impossible to get the needles through the fabric.

Another way to replace a press-off, in vogue with some knitters (assuming that the cloth is between the cylinder and dial and the first

set of dogs, and on the needles), is to keep jabbing it on to the needles a little at a time, turning the machine slowly until the first yarn guide and set of cams come to the point where the work was started on the needles; then thread the guide so that the needles will begin to knit, and proceed to place the work on the needles in continuous order, threading up the several guides as they come into position, until the other set of dogs is reached. Get the work in between these dogs by a similar process as described above, after which, continue to jab on the work continuously all the way around to the starting point, taking care that each guide is properly threaded when it arrives at

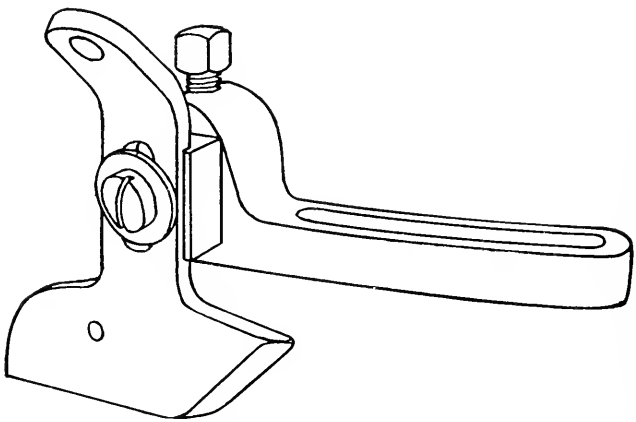
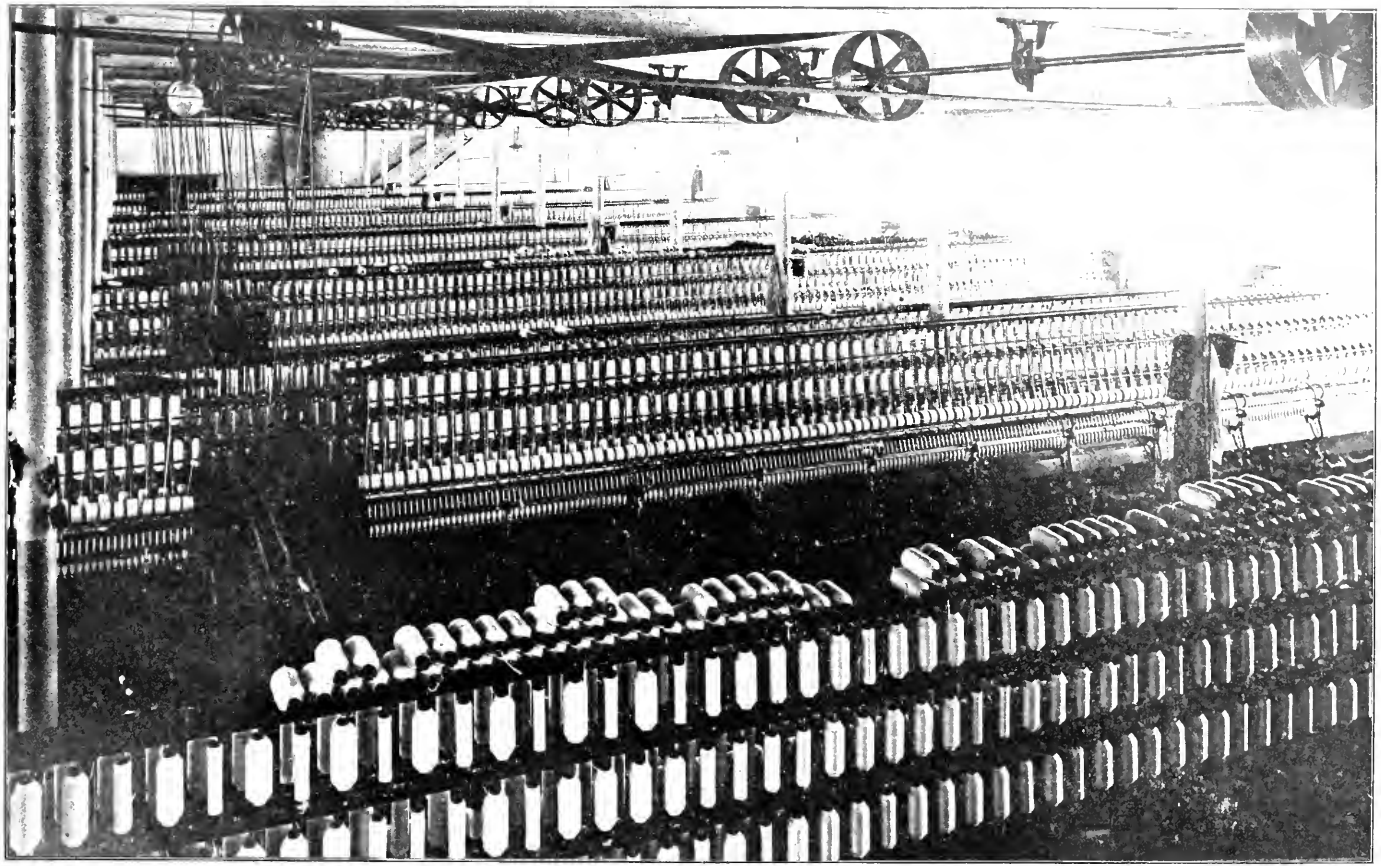


Fig. 79. Yarn Carrier.

the starting point. Then put the other end of the cloth into the take-up rolls and proceed as before.

Adjusting the Feed. Run the machine carefully until the new fabric has passed through the take-up rolls. In the meantime set all the cylinder cams evenly, by marking all the threads an equal distance from the yarn guides. To prevent unevenness of the cloth, each and every feed should draw exactly the same length of stitch. When unevenness of fabric shows in the cloth, it is often very difficult to locate the particular feeds that are not in even adjustment. The common practice of marking the yarn of each feed is the simplest, and perhaps the surest way of detecting which feeds are drawing more yarn.



VIEW IN COTTON SPINNING DEPARTMENT
Utica Knitting Co.

To do this effectively, twist the yarn between the fingers, which have been more or less soiled with oil, so that the marking on the yarn may be easily noted, then turn the machine slowly by hand until the marked places on the yarn reach their particular guides. If all the marks arrive at the holes in the guides at precisely the same time, the fabric will be even as regards the feeds. If one or more of the marked places arrive at the holes in the guides in advance of the others, it or they are drawing more yarn, and should be adjusted accordingly. The cam drawing the longest loop will necessarily draw the mark to its guide first and should be slightly raised by means of the adjusting screw; the yarn with the mark farthest from the guide should be slightly adjusted down, to make it draw a longer loop. This operation must be repeated until all the marks on the yarn arrive at the holes in the guides at precisely the same time.

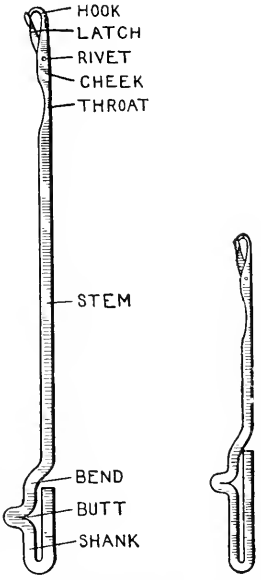


Fig. 80. Scott & Williams Needles.

Adjustment of the Dial Cap. See that all the cap draw-in cams are set to draw the head or hook of the needle through the stitch. The adjustment of the cap which operates the dial needles should bear a certain relation to the cam ring which actuates the cylinder needles. The cylinder needle should be made to draw down just in time to lay its thread on the latch directly to the rear of the rivet in the dial needle. This relation is governed by the circumferential adjustment of the cap on the center spindle.

Now run the machine long enough to get an even weight on the fabric and to adjust the take-up rolls (Fig. 81) so that they will have an equal tension on their ends so as to make the fabric pass through *evenly*. At the end of the rolls, it may be seen whether the fabric is being drawn through too fast or too slowly; for if one end is slack, it is evident that there is a lack of tension on that particular end. At each end, there is a separate adjustment by means of which the fabric

may be made to run evenly and smoothly. The take-up rolls should not be pressed together too firmly, and *must be parallel* to draw equally at both ends.

After making the above adjustments, the knitter must ascertain what weight of fabric is desired, and adjust his machines accordingly. If only a slight adjustment of one or two stitches per inch is required

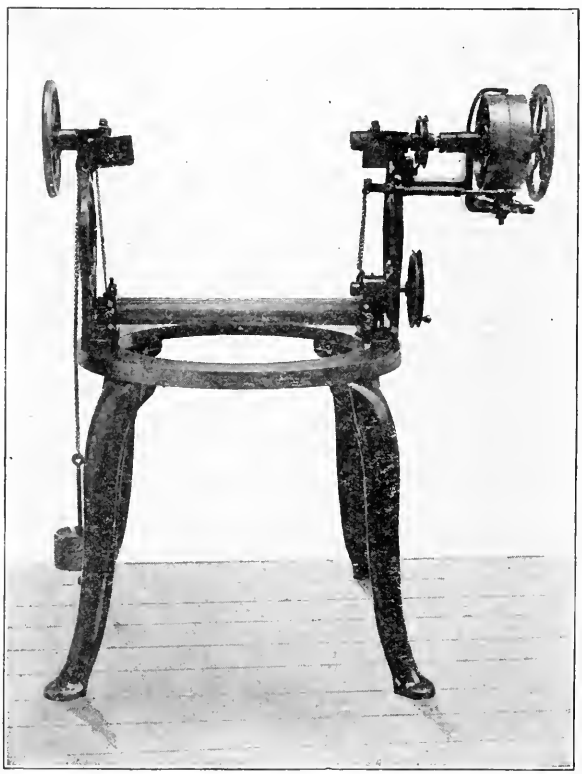
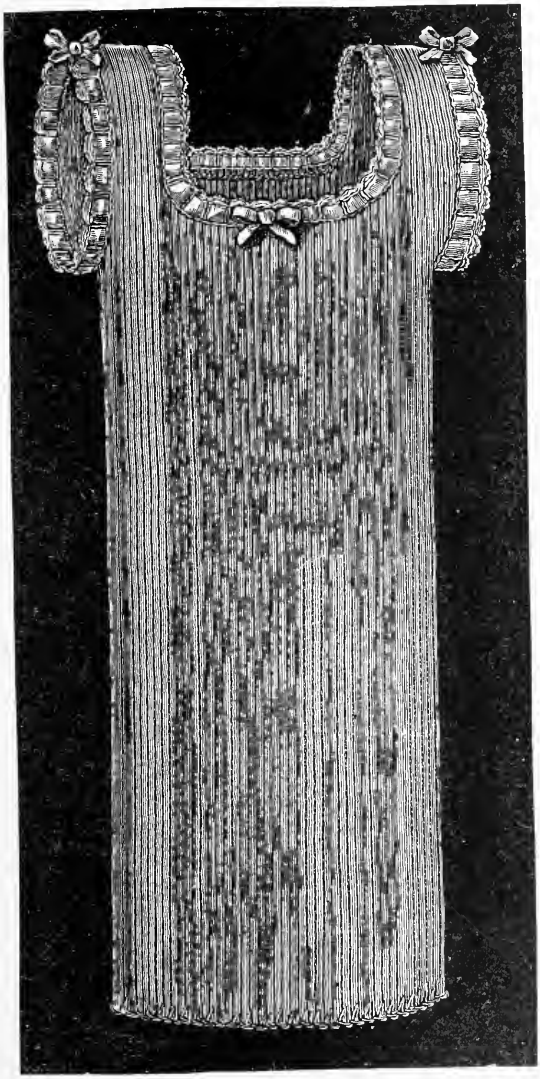


Fig. 81. Frame and Take-Up.

to obtain the proper weight of fabric, it can be made by adjusting the dial spindle wheel; but for more than one or two stitches per inch, the adjustment should be made on the cylinder draw-down cams. This adjustment requires the marking of the yarn, as previously described, to ensure a perfect evenness of the fabric, after the proper weight has been obtained.

To Slacken the Fabric, either lower the draw-down cam in the

ring, so that the needles will draw more loop, or raise the dial by loosening the retaining screw in the cross-bar, then turn the dial



Ladies' Swiss Vest.

spindle wheel in the direction calculated to raise the center spindle; the cap and dial will come with it. As a rule, it is not good practice to have the dial any higher than just enough to give ample space to

permit of a free passage of the thickest portion of the work; further slackening of the cloth should be obtained by adjusting the draw-down cam in the ring, as stated heretofore.

To Remove a Section of the Sectional Cam Ring. The sectional cam ring is provided for the purpose of obtaining easy access to the needle cylinder so as to remove and replace a broken needle or broken cam without removing the entire ring. After releasing the tension from the work by slackening the take-up rolls, take out the retaining screw which passes through the solid outer ring, and remove the central section. Now, it will be possible to draw the cam section away in a direct line from the needle cylinder and disclose the needle cylinder, so that the difficulty may be located, and the broken needles or cams removed and replaced by new ones.

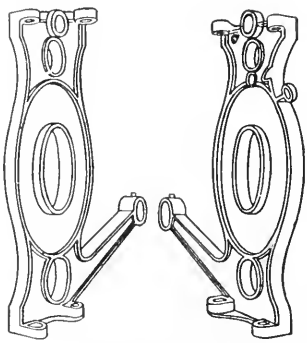


Fig. 82. Housing Plates.

To *restore the sections* to their proper places, raise all the needles to a plane above the cams of the lower section; force this section up to the cylinder, drop in the central section, and secure with the retaining screw. Draw the work down through the take-up rolls, and readjust it to get the proper tension on the cloth between the cylinder and take-up rolls, turning the machine partially around by hand to see that everything is working properly; then ship on the power.

In Readjusting the Cylinder Cams, it is necessary that the dial needle should draw back within the dial only sufficiently to ensure the knocking over of its stitch; any additional draw means an unnecessary strain on the fabric, which will produce bad work.

In Adjusting the Yarn Guide, the latches of both sets of needles should not be permitted (by the guide) to close down on the hooks of the needles. The forward end of the guide is supposed to intercept any latch that may be inclined to fly shut. It is also important to see that the guides occupy such a vertical position that there is sufficient room for the hooks of the dial needles to pass under the lower edge of the guide.

When the fabric is being examined to see that the knitting is perfect and clear of any tuck stitch, it will be found that the holes

and tuck stitches often occur through the failure of the cap draw-in cams to draw the needles clearly through the stitch. If the machine is cutting holes in the fabric, *without* the presence of the tuck stitches, it may be prevented by setting the cap draw-in cams *outward*, as too much strain at this point cuts the yarn when knitting.

The cylinder not only holds the lower needles, or needles for making the outside of the fabric, but the cylinder top or comb acts as a *landing* or *knocking over* point for the cylinder needles. The

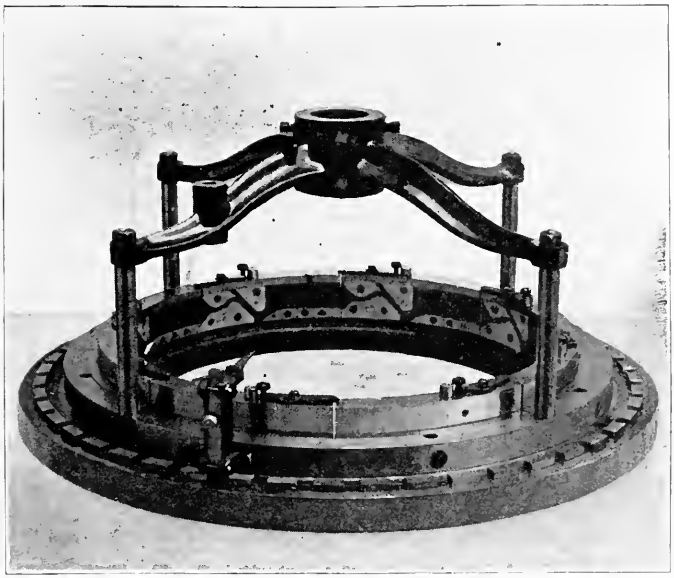


Fig. 83. Cam Cylinder, Showing Relative Positions of Cams, Cross-Bars, Etc.

cylinder cap or comb also acts as a knitting point for making the welt on a welting machine, as the dial needles are thrown out of action at this point of knitting.

The Dial is not only a plate to hold a given number of needles according to the gauge of the machine, but it has another function to perform, in that the outer edge, or sinkers, of the dial act as a *landing* or *knocking over* point for the dial needles on the inside stitch.

The Take-Up besides being present to perform its function of taking the knitted fabric from the needles as it is being made by the succeeding courses formed, is also employed as a weight or tension

to assist the opening of the needle latches, when the needles are clearing the old loops, prior to forming a new stitch. The take-up is also an important factor in *forming the loops*, as it is necessary to employ weight enough to carry the old loops out of the path of the needles without cutting the fabric.

The take-up on the "revolving cylinder" type is called a friction take-up, and on the "stationary cylinder" types it is called a gravity or balance take-up.

NUMBER OF NEEDLES.

The following table gives the total number of needles in each size machine, and the number of cuts in the cylinder, when the number of needles per inch is given, from 7 inches in diameter up to 24 inches in diameter.

The numbers given below are the nearest numbers to the rate given that will divide by three, for making two and two fabric.

	4 to 1	5 to 1	6 to 1	7 to 1	8 to 1	9 to 1	10 to 1	11 to 1	12 to 1	
7″	87	108	132	156	174	198	222	240	264	7″
8″	99	126	150	174	204	228	252	276	300	8″
9″	114	138	168	198	228	252	282	312	336	9″
10″	126	156	192	222	252	282	312	345	375	10″
11″	138	174	207	240	276	312	345	372	414	11″
12″	150	192	228	264	300	336	375	414	456	12″
13″	165	207	252	288	324	375	408	444	504	13″
14″	180	222	270	312	354	396	444	480	540	14″
15″	192	240	288	336	372	432	480	516	576	15″
16″	204	252	306	354	408	456	516	558	612	16″
17″	216	270	324	375	432	480	540	588	648	17″
18″	228	282	342	396	456	516	570	624	690	18″
19″	240	300	360	420	483	540	600	660	720	19″
20″	252	318	384	444	504	576	624	690	768	20″
21″	264	336	396	468	540	600	660	732	804	21″
22″	282	348	420	492	552	624	690	768	840	22″
23″	288	372	444	504	588	660	732	804	876	23″
24″	300	384	456	540	612	690	768	840	912	24″

It is a good practice to use eight needles to the inch for shaped goods, and ten to eleven needles to the inch for straight goods.

GEARING.

The gearing of each machine differs as to the size of the machine, but as a rule, like size driving pulleys on the driving shaft will produce the correct proportionate speed in the various sizes.

Detail of gearing and particulars of driving are contained in the following table.

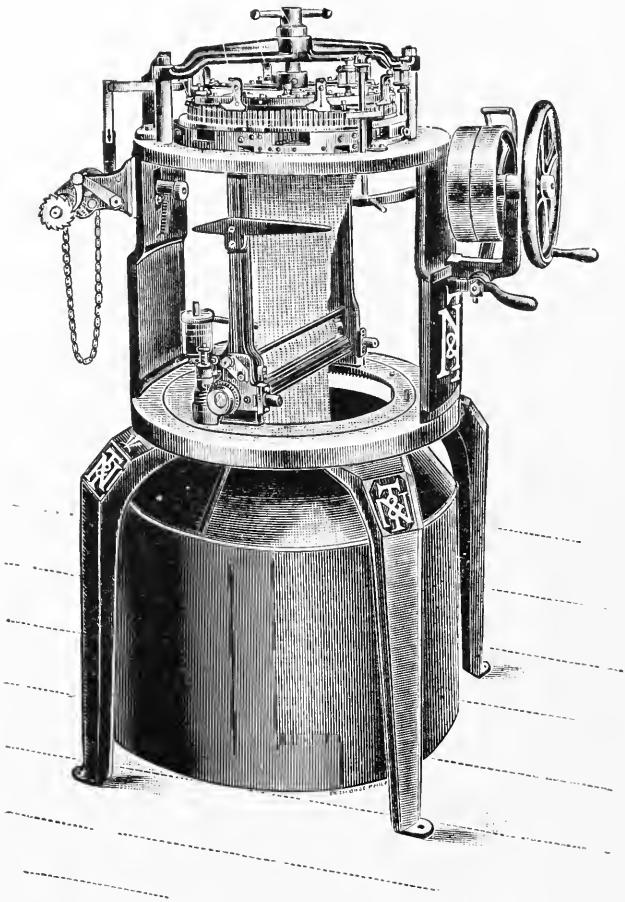
DIAMETER OF CYLINDER	SPEED OF HEAD	TEETH IN RING	TEETH IN PINION	DIAMETER DRIVING PULLEY	WIDTH DRIVING PULLEY
7 in.	68 rev.	152	30	7 in.	$1\frac{1}{8}$ in.
8 "	64 "	164	30	7 "	$1\frac{1}{8}$ "
9 "	60 "	140	28	7 "	$1\frac{1}{8}$ "
10 "	54 "	150	28	7 "	$1\frac{1}{8}$ "
11 "	50 "	136	28	7 "	$1\frac{1}{8}$ "
12 "	46 "	145	28	7 "	$1\frac{1}{8}$ "
13 "	42 "	153	28	7 "	$1\frac{1}{8}$ "
14 "	38 "	161	28	7 "	$1\frac{1}{8}$ "
15 "	34 "	169	28	7 "	$1\frac{1}{8}$ "
16 "	32 "	176	28	7 "	$1\frac{1}{8}$ "
17 "	30 "	185	28	7 "	$1\frac{1}{8}$ "
18 "	28 "	195	28	7 "	$1\frac{1}{8}$ "
19 "	27 "	205	28	7 "	$1\frac{1}{8}$ "
20 "	26 "	210	28	7 "	$1\frac{1}{8}$ "
22 "	25 "	214	28	7 "	$1\frac{1}{8}$ "
21 "	24 "			7 "	$1\frac{1}{8}$ "

The speed given here is a good average, but certain conditions require, perhaps, a lower speed, and on the other hand, may admit of an increased speed. This is wholly a matter of judgment with the knitter, for the nature of the yarn, its condition, the manner of winding and the climatic influences; in addition to the many other things that are not infrequently coming up to enter into the calculations of speed, are the most important factors in securing a large production. When the yarn is running well, the speed should be increased judiciously. If it runs poorly and all other conditions are in their most favorable running order, the speed of the machine will have to be reduced to a point that will manipulate the yarn without too many stops.

LEIGHTON FLAT HEAD LATCH NEEDLE MACHINE.

This type of latch needle circular machine, Fig. 84, differs materially from the customary build of latch needle machines, in that the plate or horizontal needles are operated *outside* of the cylinder *towards* the center, instead of *from* the center *outwardly* to the edge of the cylinder. This is the reverse of the customary position of the cylinder and dial type of machine. In this type, the horizontal or plate needles form the outside stitches, and the cylinder needles form the inside stitches of the fabric. It is the Leighton development of the Walter Aiken machine.

Dial Needle Plate. Fig. 85 represents the dial needle plate, and illustrates the principle on which these machines are built. As the needles are operated from the outside towards the center, and the butts of the needles on which the actuating cams operate are farther from



Nye & Tredick Circular Latch Needle Machine
of the Revolving Head Class.

the center, the lands are thicker and stronger. The butts of the needles being wider apart than the gauge (at the inside edge of the needle plate) the yarn is taken into the machine with very little strain or stress, because each needle nearly completes its stitch before the next needle engages the yarn at the carrier; in this respect, somewhat

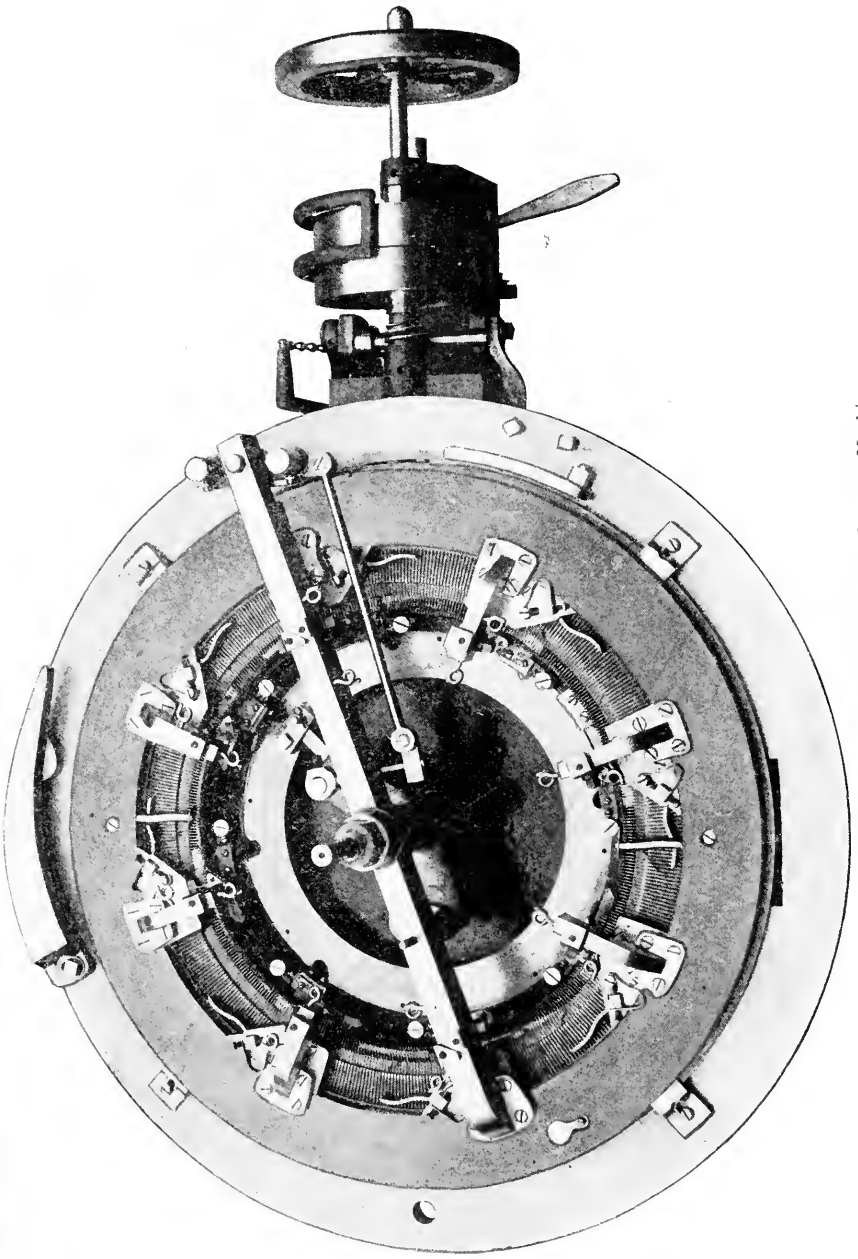


Fig. 84. Top View of an 8-Feed Automatic Underwear Machine.

resembling the operation of the spring needle frame in forming its stitches. This feature admits of using a large range in size of yarn on the same gauge machine, though cylinders and needle plates of different gauges may be used in the same machine.

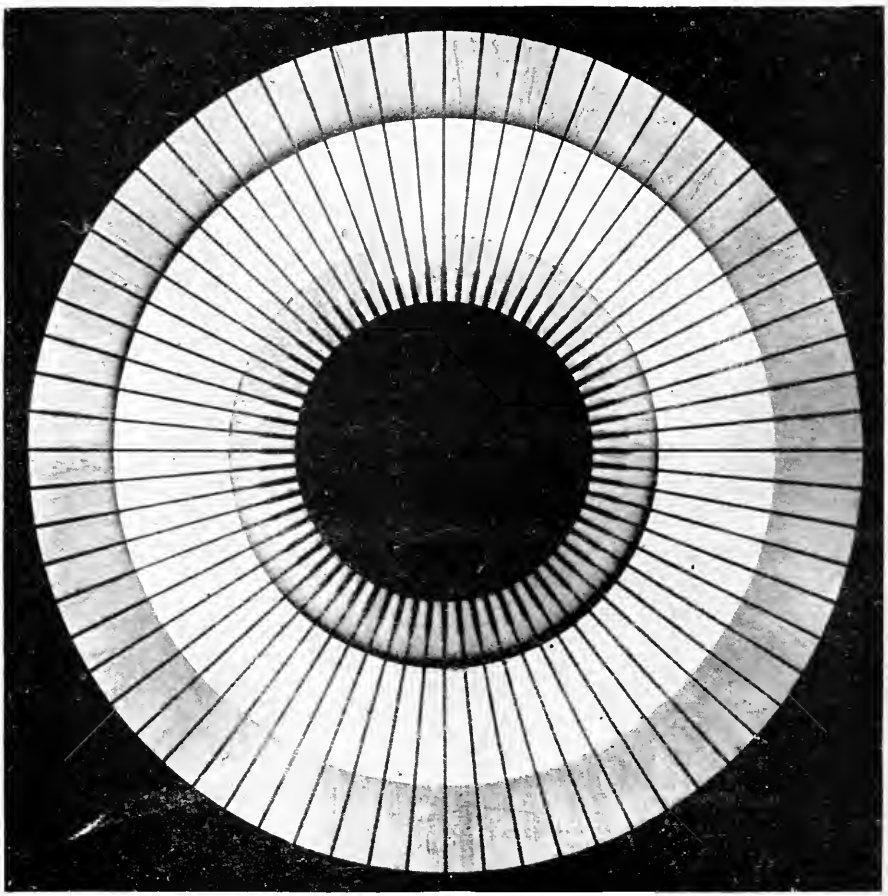


Fig. 85. Needle Plate.

Shogged or Racked Stitches. Among the other notable features of this machine, is the *shogged* or *racked* stitch, which forms the much desired edge for sweaters (Figs. 86 and 87) and other knitted garments. These stitches are made after knitting the body with the half cardigan, or royal fancy, the plain rib, or other stitches, as the

character or style of the garment may require. The shogged edges are formed automatically for any desired length at predetermined intervals, or may be made in a continuous, automatically racked web.

If it is desired to produce a fabric with equal intervals of shogged and plain stitches, or other stitches alternating, or a racked, or shogged portion of fabric to form the bottom of the garment, the machine can be regulated, by means of the pattern chain, to effect such result automatically.

Plated Goods. Another feature, is in knitting plated goods, *i. e.*, both sides of wool yarn, with cotton yarn between. This, of course, can be done in any combination of wool, cotton and silk, or other yarns, as the character of the cloth, or the demand for a fabric, may require.

These machines are designed and built for knitting straight, circular web, either plain rib, half cardigan, or tucked stitch, as used principally in making Swiss rib vests, pants, etc. Another style is for producing a variety of fancy knit combinations of stitches, in addition to the above, and also the regular fashioning machine, which automatically changes from plain rib to half cardigan or tuck stitches, as does any "automatic" for knitting underwear.

The sleeves may also be fitted with the racking attachments, where it is desired to have a racked edge or finish to the cuffs, which will produce tubular ribbed cuffs with racked or shogged borders and edges, making a complete finish for the cuffs as illustrated in Figs. 88 and 89.

Fig. 90 illustrates the *circular ribbed sweater collar*, showing automatically racked courses, made on the collar machine of this same type, which makes a circular collar with racked or finished edge, and with a variety of racked courses throughout the collar, as may be noted in the illustration. The machine works continuously, and automatically racks the courses as it knits.

Fig. 91 represents the *sweater* and *cardigan jacket machine*, with double feed and striping attachment, and automatic racking attachment, that racks borders and bands of any width and at any part of the web, without attention from the knitter.

Another important and desirable feature of these machines is the *separating course* of knitting (see across the middle of Figs. 86 and 87), which enables the operator to separate the goods without cutting the fabric, leaving a clean, smooth, finished edge.

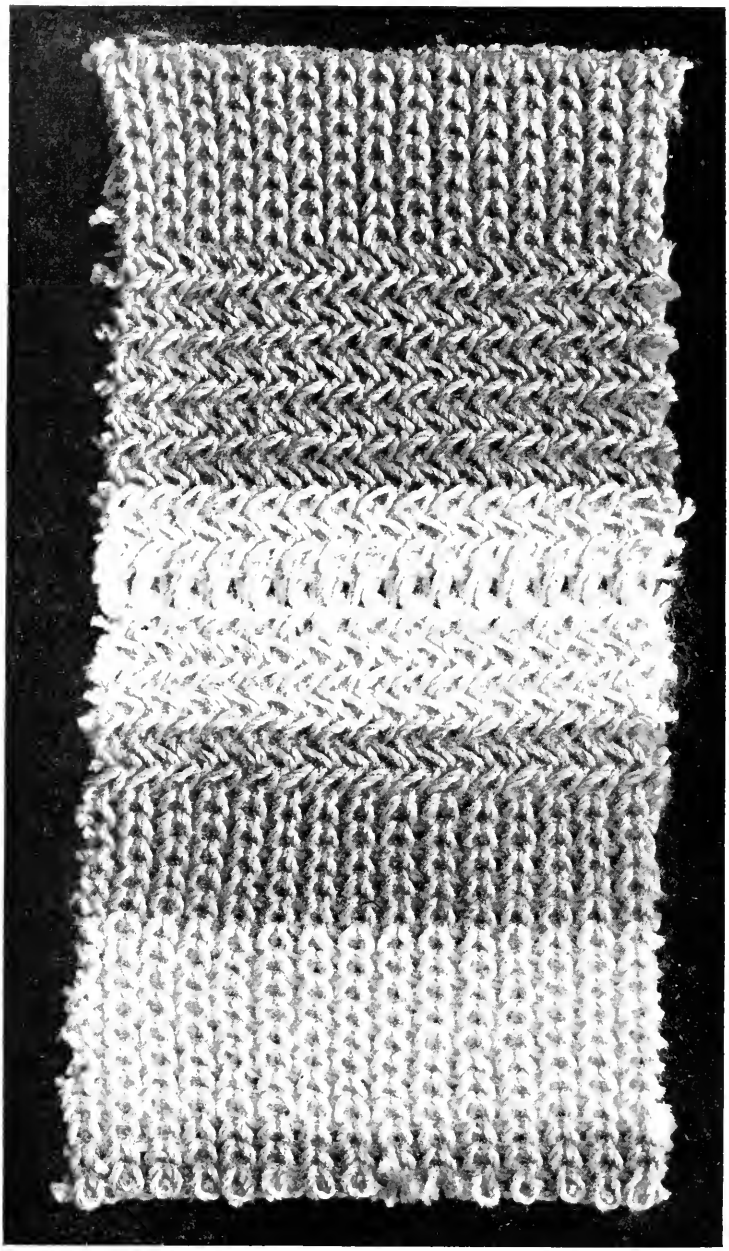


Fig. 86. Face of Sweater Cloth, Showing Separating Course and Racked Stitches.

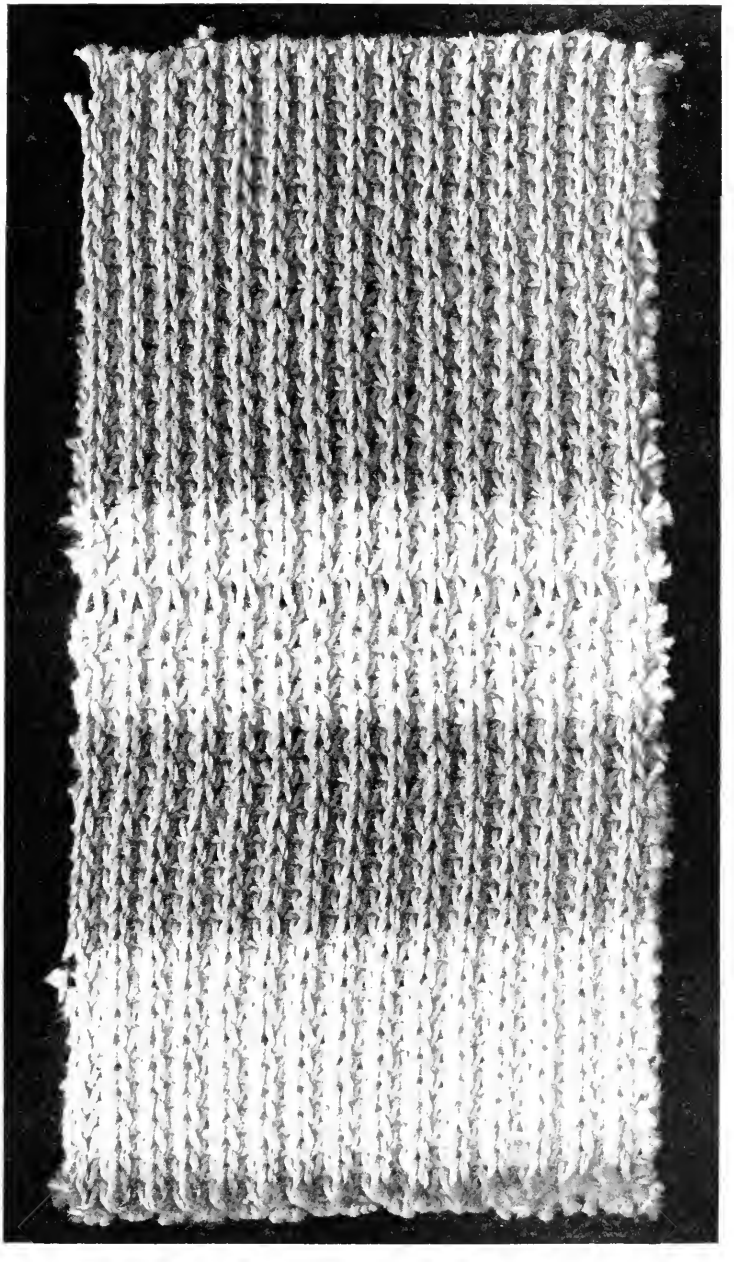


Fig. 87. Back of Fig. 86. Racked Courses do not show on the Back.

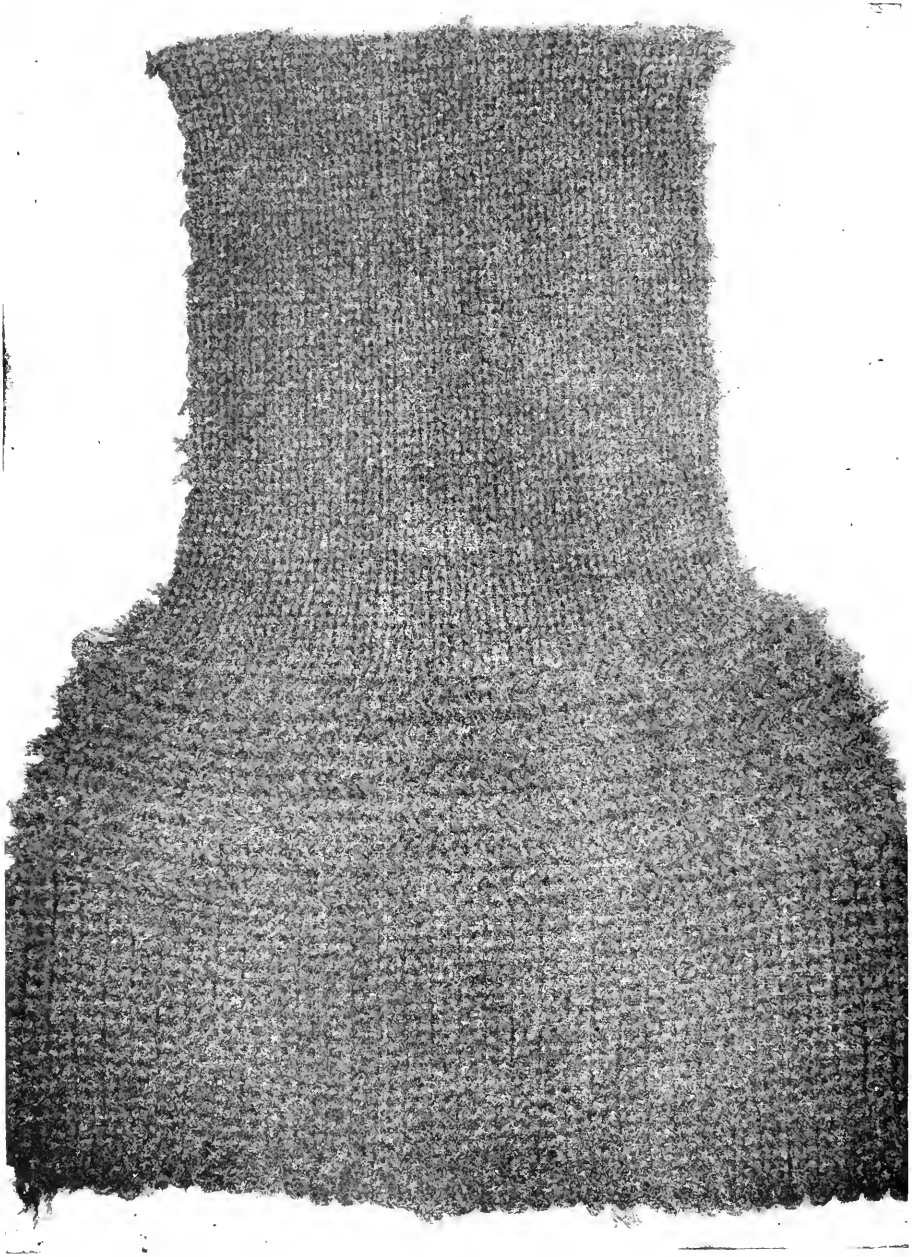


Fig. 88. Cuff-Racked Face.

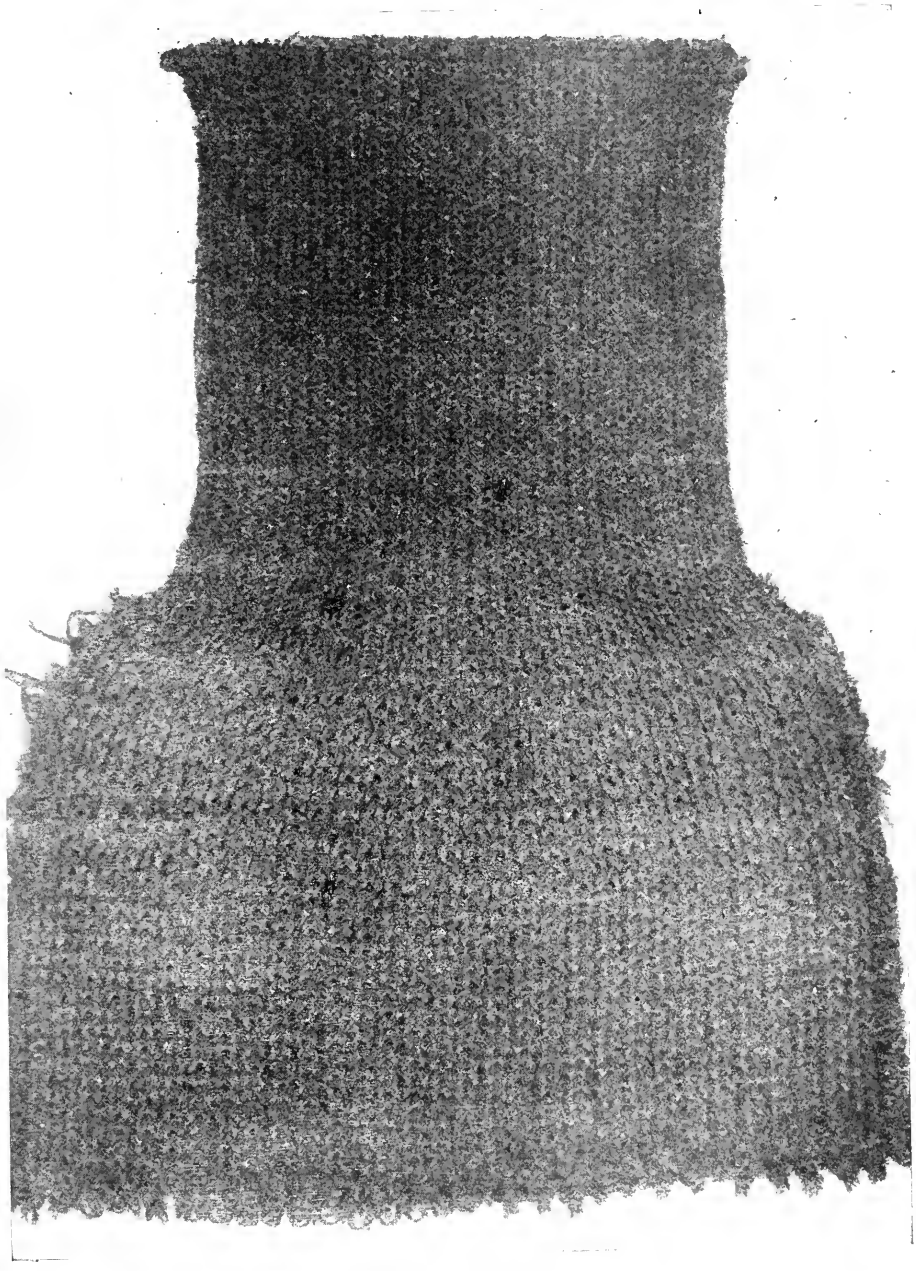


Fig. 89. Cuff-Racked Back.

Fig. 92 represents the sweater machine tipped partly over, in order to give a more comprehensive view of the top of the machine, and shows why the name "Flat Head" Circular Knitting Machine was so distinctively applied to it.

Method of Driving. The bed plate A, (Fig. 93), has the exten-

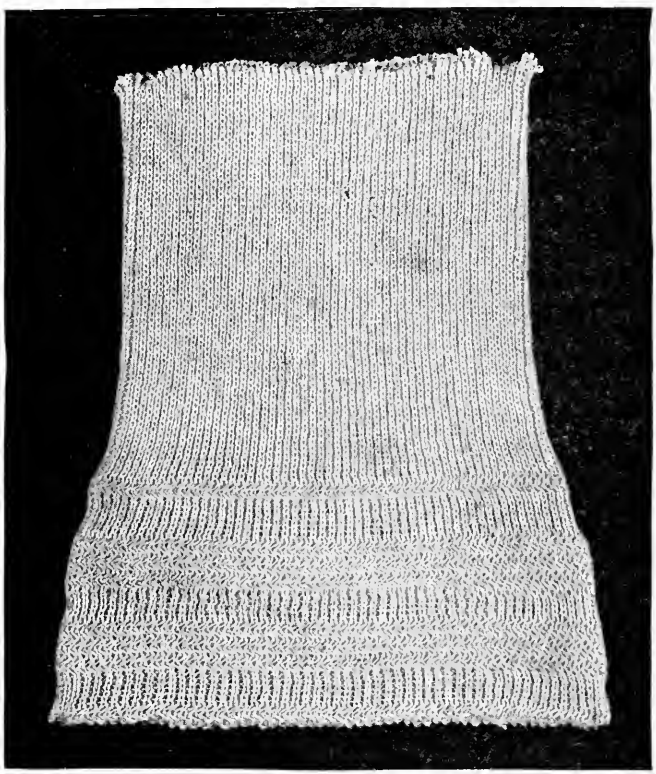
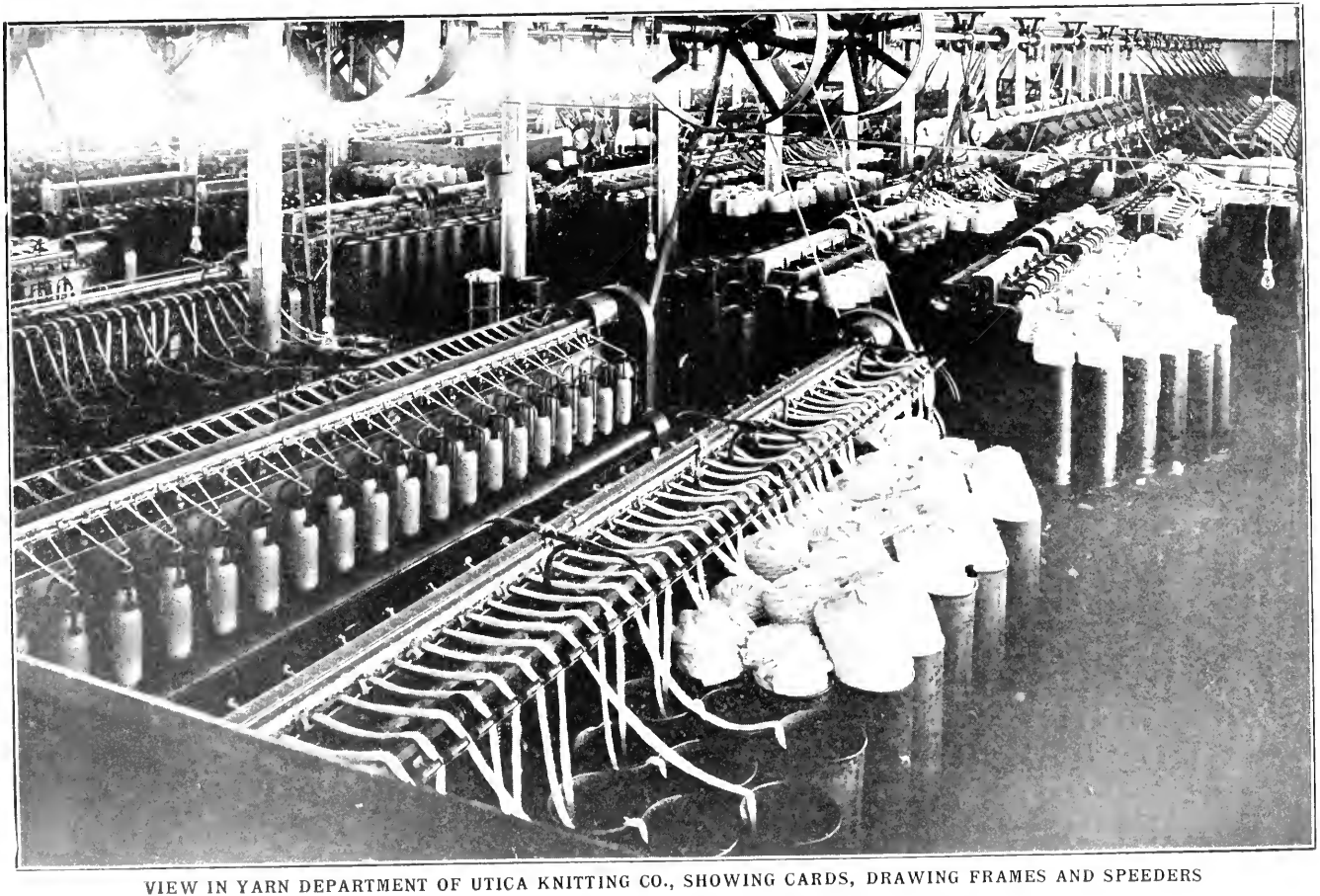


Fig. 90. Circular Ribbed Sweater Collar. Racked Courses.

sion A^1 to furnish bearings for the main shaft, which is provided with tight and loose pulleys, and has a bevel gear, or pinion, which engages the teeth of the dial cam plate A^4 to rotate it. The bolt A^{13} on the yoke A^5 enters a link A^{14}, which is pivoted on an arm A^{15} projecting from the shaft of the cylinder actuating cam hub B^2 (See Fig. 94), so that the hub will revolve in unison with the dial plate. The yoke A^5 is connected to the cam plate by means of screws and supports, depend-



VIEW IN YARN DEPARTMENT OF UTICA KNITTING CO., SHOWING CARDS, DRAWING FRAMES AND SPEEDERS

ing from it is the central shaft A^5 (See also Fig. 94), having the attached collar A^6 on which rests the hub of the large ring-like washer B loose on the shaft. The needle cylinder B^1 is supported on the

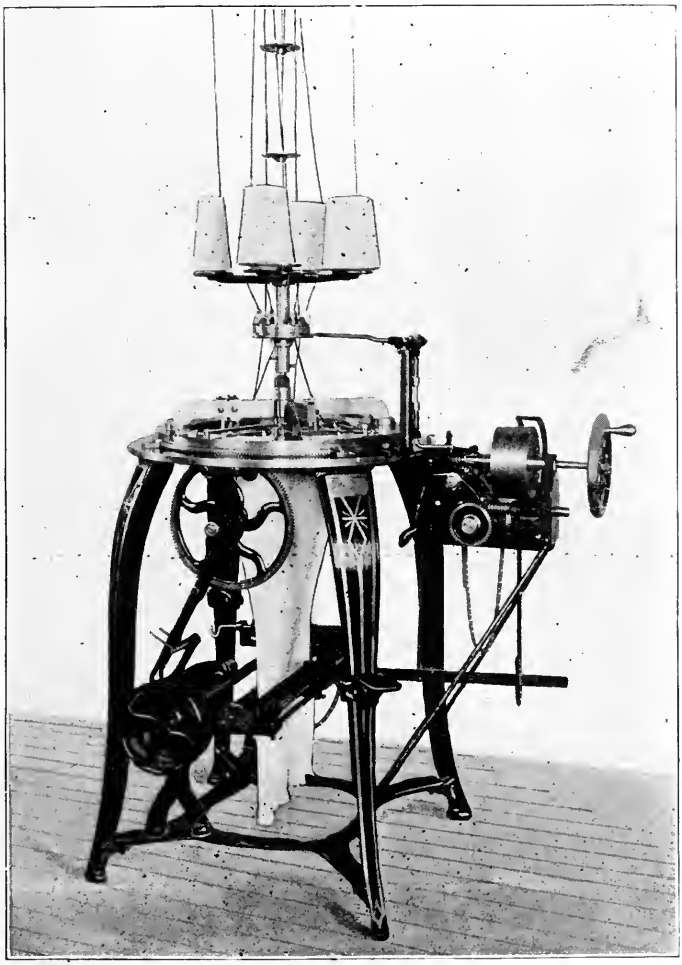


Fig. 91. Sweater and Cardigan Jacket Machine.

washer B, and prevented from rotating with the shaft by its projecting rib *a* engaging the fork B^3. When the cam plate is rotated, the hub carrying the cams turns in unison with it and the needles in the stationary cylinder are thereby actuated to form their stitches, and the

movable cams or projections a^5 a^6 in the groove a^4 actuate the dial needles in the stationary needle dial plate 3, which is a part of the bed plate A. (See also Figs. 93 and 94).

The Dial Needle Bed. The dial needle bed is composed of two

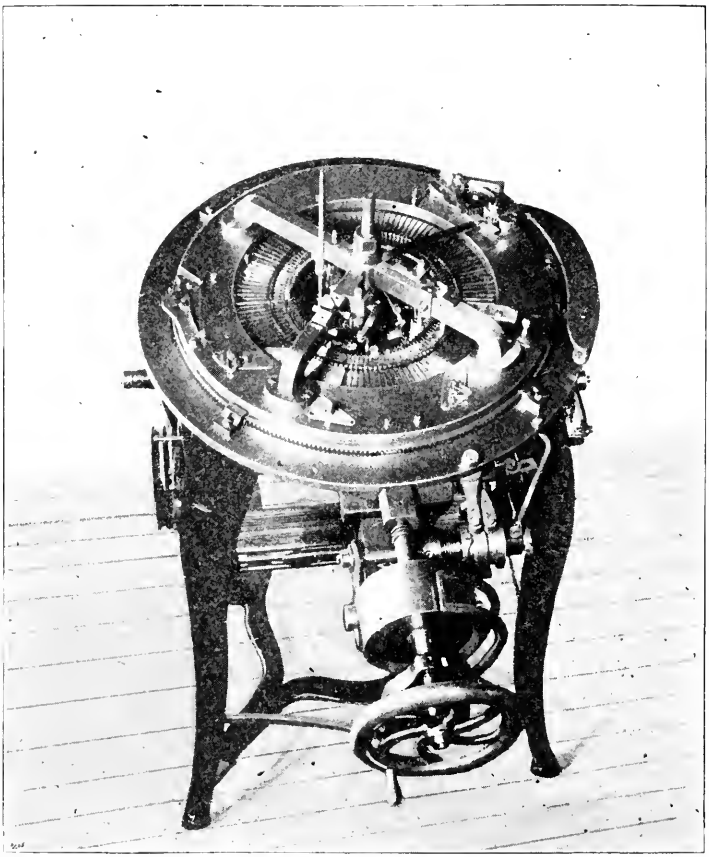


Fig. 92. Sweater and Cardigan Jacket Machine-Top View.

ring-like pieces 3 and 4, (See Fig. 95), which are bolted together, and the part 3 is connected with the frame bed A, the central part being grooved for the reception of the needles; the parts 3 and 4 being so shaped and attached as to leave a circular space in which is placed the segmental racking guides C.

The Racking Mechanism. (Fig. 96.) The racking guides C have

fastened to the under side the studs c, which are extended down through slots in part 4 of the dial needle bed and connected to a block c^1 sustained in place by a nut c^2. These blocks are connected by means of links c^3 c^4 to levers c^5 c^6, having a common fulcrum. Each

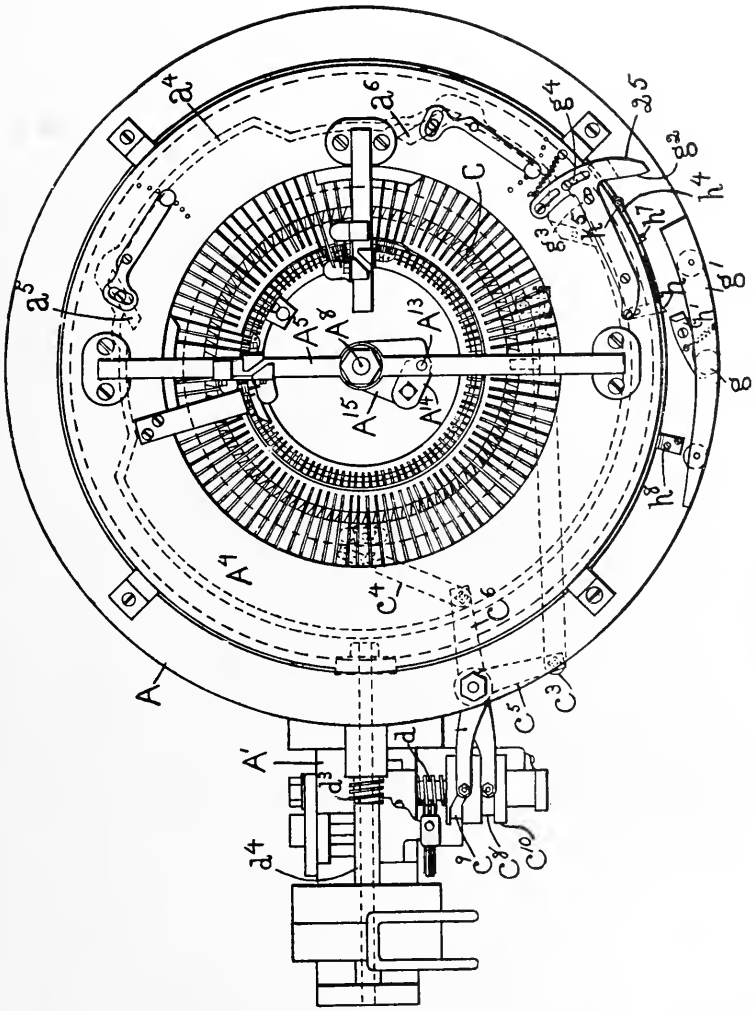


Fig. 93. Bed Plate and Driving Mechanism.

lever having a cam roller entering one of two grooves in the periphery of the cam hub c^{10} fastened to shaft d, having loosely mounted upon it a worm gear having its sleeve inserted in a bearing made in the

extension A^1, the gear being engaged and rotated by a worm d^3, carried by a sleeve d^1, fast on the continuously rotated driving shaft A^2. (See also Fig. 93).

The worm gear forms part of a clutch mechanism illustrated at Fig. 66 (Part II), so arranged that during the regular knitting, motion is not transmitted to the racking mechanism. This is accomplished by means of a pattern chain mechanism, which by means of the high and low links in the pattern chain, controls the clutch that

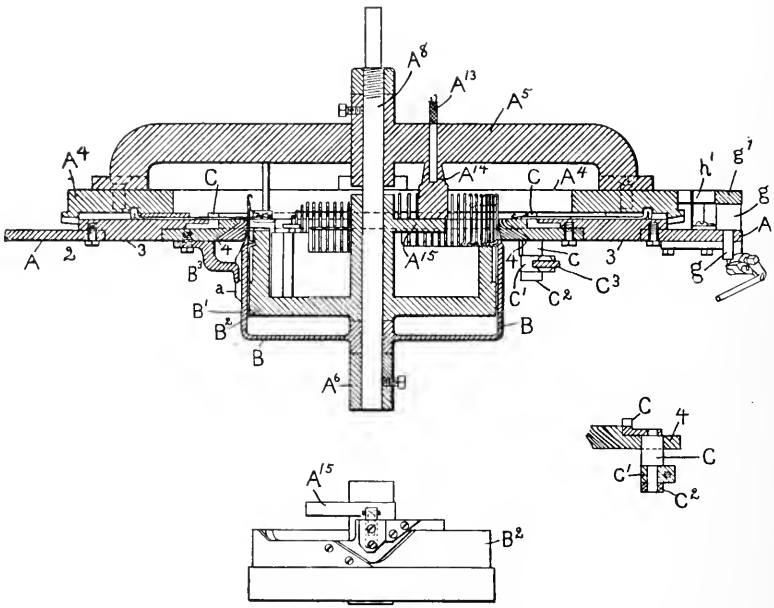


Fig. 94. Sectional View of Head.

lets the worm wheel start the shaft d and cam c^{10} at such times as predetermined to rack or shog the stitch, by deflecting the needles a little back of their hooked ends, putting them a little to one side of their true radial positions, so that they may, for some stitches, pass certain of the cylinder needles at one side, and for other stitches, pass the same needles at the other side, and remain in either of their two or changed conditions to knit any desired number of courses.

Fig. 95 shows part of the dial needle bed, dial cam plate, the top of the cylinder needle cam grooved for the cylinder needles, and the

cylinder needle bed, with some of the dial needles, the parts being in position for regular knitting. Needle 21, in the lower diagram of Fig. 95, if pushed forward, will enter the space between the grooves 5 and 6 for the cylinder needles; but when the racking guide C is moved to rack the needles, they will be moved, as in the upper diagram of Fig. 95, so that the needle 21 will pass to the right of the groove 5 and the needle 22 will enter the space between the grooves 5 and 6.

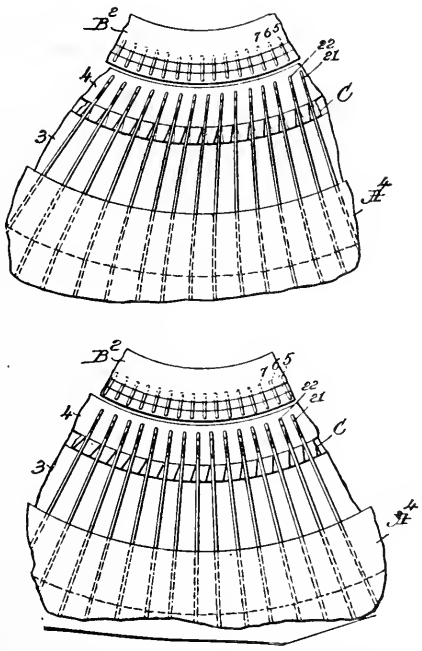


Fig. 95. Part of Dial Needle Bed, Cam Plate, etc. The Needles and Racking Guide in Different Positions.

This change of position of the dial needles, causing them to enter between different cylinder needles from those with which they co-operate in regular knitting, makes a change of stitch, and the stitch is designated as a "*racked*" or "*shogged*" stitch. The links on the pattern chain act at the proper and predetermined time to throw the racking mechanism out of action, and the regular knitting is resumed, unless it is desired to introduce the separating course to make a finished edge.

The Separating Course. (See Fig. 86.) One garment being

knitted, to form a finish for the next garment, a separating course is made by casting the stitches from the dial needles. To do this, the dial needles are given an inward motion by a movable throw-in cam, which enables all the loops held on their shanks, to be brought behind the latches. To effect this, a link, Fig. 96, just at the rear of the series of high links used for racking, is provided at its side, with a pin 24, which acts on an arm f, fixed on the rack shaft f^1, which then, by means of its connections, causes the rod g to rise, lifting the cam plate g^1, raising it into operative position.

When the cam plate is lifted, it is in position to be struck by the end 25 (Fig. 93) of the lever g^2, which, in its inward movement carries with it the cam g^3, pivoted to the dial needle plate at g^4, causing the plate in its new position to act on the butts of the dial needles, and move them inwardly far enough for their latches to pass through the loops on their shanks, so that the dial needles, when drawn back, are enabled to cast off the work previously held upon them. The movement of the lever to move the cam g^3 into its extreme working position, also acts to push outwardly a stop h', so that it meets the catch h^1, which acted temporarily to engage in a notch and hold up the rod g, letting the rod and cam g^1 immediately drop. When the lever g^2 is pushed in, it should be held in for one rotation of the dial plate, and to do this, is provided the latch h^4, pivoted on the dial cam plate at h^5, and kept in place by a spring. The latch at its opposite end, has a heel, which in the rotation of the dial cam plate, meets the top of an inclined lug h^8, which immediately effects the release of the lever g^2, letting the spring draw it back into its normal position, after the separating course is made.

Tuck or Royal Rib. As rib knitting is commonly done on two sets of needles, when the fabric is made of that form called tuck or royal rib, it is customary to place the needles of one set in side position with relation to the thread guide, or guides used to supply such needles that they will receive the yarn, but will not be immediately withdrawn far enough to cast off their loops and knit. These same needles, however, knit when brought into such relation to a second thread guide that they may receive the thread, the needles casting their loops and knitting after they have taken the thread from the second thread guide, or from the same thread guide the second time, as when there is but one thread guide.

The thread guides referred to always supply threads to the needles, whether knitting tuck or royal rib, or plain rib. When tuck or royal rib is being knitted, the needles actually knit only at alternate thread guides, consequently but half the number of courses will be knitted as when plain rib is being made, for during the knitting of plain rib, every needle knits its thread before taking another thread.

Royal Rib or Tuck Stitch. The royal rib or tuck stitch differs from plain rib knitting only that in plain rib knitting, the cylinder needles, after receiving a thread, are actuated to knit *before receiving another thread;* whereas in royal rib or tuck stitch, the hooks of the

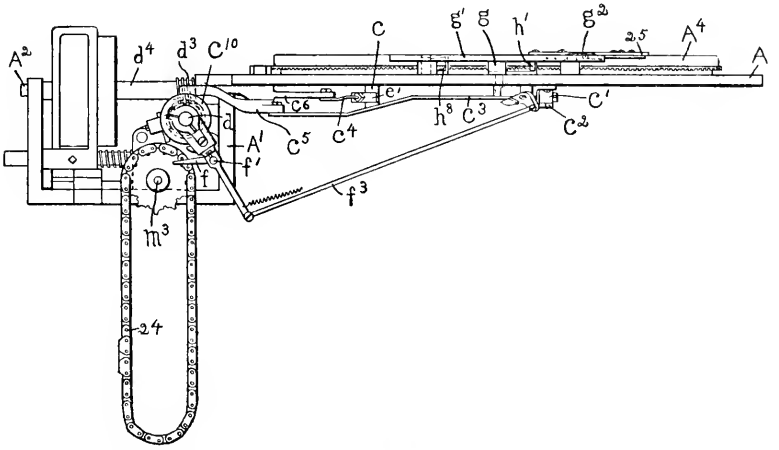


Fig. 96. Side View of Head and Mechanism for Controlling the Movements of the Dial Needle Racking Guide.

cylinder needles are provided with *two threads* before the needles are depressed to knit.

Welts are commonly knit on the needles of a rib knitting machine by temporarily discontinuing the action of one set of needles, putting them out of action yet permitting them to hold their loops. After a few courses of knitting have been effected on the one set of needles, the loops of the last course of the welt are joined with the loops held on the stems of the needles which had been temporarily put out of action. When knitting a welt with one set of needles only, the length of the welt is limited to the number of loops, or courses, that the needles will accommodate without loading up to the danger point.

STARTING UP A LEIGHTON MACHINE.

The machine should stand perfectly level after being fastened to the floor. The driving shaft should be speeded to allow the driving pulley to be about ten inches in diameter to avoid undue strain on the belts, and the consequent wearing of the shaft bearings. The bobbin stand on the spindle of the machine should be adjusted in position to connect the chain of the load-up stop motion with the stop-dog on the bobbin stand, and fastened to the spindle with the set screws provided for that purpose.

The *needles should be inspected* to see that they are all lying properly in their grooves, and that none are partly out, or otherwise disarranged. The *yarn guides* should be set in position to deliver the yarn into the hooks of the needles, and the latch openings adjusted to go through the hooks of the needles in the proper manner. Put on the yarn and turn the machine a few times, in order to make sure that the yarn guides are properly adjusted to perform their function, and are feeding the yarn to the needles without hindrance.

Adjust the weight on the take-up so that the web is fairly taut when touched with the hand; the weight should be moved farther out on the arm for heavy yarns, and for very light yarns, the weight may be removed entirely. Sometimes when using the lightest yarns, it becomes necessary to hang a light weight on the small hook in front of the take-up.

When there is a web on the needles, it is only necessary to thread up each feed and start up the machine, then, when a short length of fabric has been knitted, it is well to examine it to see that the stitches are all being made the same length. If one feed is drawing in yarn faster than the others, or some feeds are drawing in less yarn and making shorter stitches than others, they must be adjusted to all draw alike, and thereby make the stitches even. To do this, mark each yarn the same distance from the guide or carrier, and note which feeds use it up the fastest. The draw cams are provided with an adjusting screw for the purpose of adjusting the cam in or out, to shorten or lengthen the stitch, as the conditions may require. The cylinder needles should be allowed to draw sufficient thread to cast off their stitches freely.

In this "Flat Head" type of machine, the horizontal or plate

needles regulate the amount of yarn consumed in making the stitches, and it is very seldom necessary to raise or lower the cylinder, the only object in doing so being to allow sufficient throat for the web to pass through freely from the needles. When the stitches are all evened and a perfect fabric is being knit, make up the garment measuring chain, so that it will give the desired length to the garments

Dropping Stitches from the plate needles, or the outside of the web, is generally owing to the yarn guide being too high above the needles, thereby allowing the yarn to slip over the hooks of the needles; or it may be caused by the latches flying shut, as they pass through the stitch. The yarn guide should guard them at this point and keep them open. Another cause for dropping stitches is that the stitch may lift off the hook if the stitch steels are too far back of the yarn carrier when the needles push forward after drawing a full length of stitch; the steel on which the hook rests should move from under that needle, by the time the hook reaches the *edge* of the steel, otherwise the steel may lift the stitch off the hook.

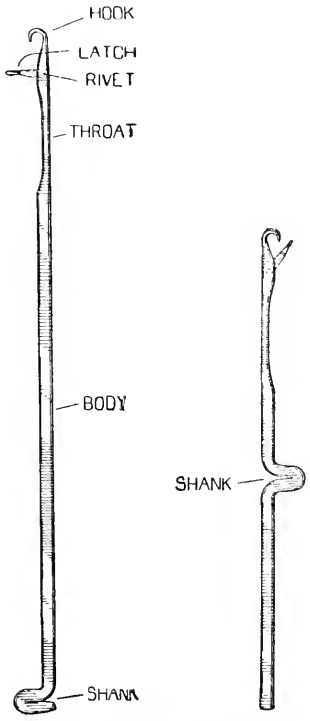


Fig. 97. Leighton Needles.

If the stitches are dropping on the *inside* of the fabric, the cylinder cam plug may be set too far forward, and the cylinder needle latches may fly closed just as they rise through the stitch. The yarn keeps these latches open if the cam plug is not too far ahead; on the other hand, if the cam plug is set too far back, the yarn will be laid behind the cylinder needle latches and close them up. When the cylinder plug and the plate needle are matched correctly, the cylinder needle will be drawing its stitch, just as the plate needle is coming forward over the steel.

Large holes in the work are usually caused by a *defective needle*

with either a crooked latch or a bent hook. Small holes are usually caused by *knots in the yarn*.

A rough stitch along one of the ribs in the web often indicates a *loose rivet* in the needle, and as all such marks in any one or more ribs can be easily traced to its needle, by following up the rib on the outside of the cylinder, such causes for poor work can be easily detected

Face. 2 and 1 Ribbed Fabric.

and remedied by replacing the imperfect needle with a perfect one. *Broken needles* may be taken out of the cylinder or plate any time, without removing the keys or slides.

If the trouble is that the yarn breaks, it can, in many cases, be located by examining the ends of the yarn. If the ends of the yarn

look as though they had been cut off squarely, as with scissors, it will, as a rule, be found to have been cut by the latch of the needle shutting on the thread; if the ends of the yarn are fine and tapered, the cause may be found to be a twist in the yarn; if the ends are long, and look untwisted, the cylinder needle is probably drawing its stitch

Back, 2 and 1 Ribbed Fabric.

before the let up of the plate needle in which case, the cam plug should be let back a trifle. This is accomplished by means of the adjusting screw in the bottom, which connects the plug with the yoke of the machine.

If a quarter should from any cause run off the needles, push the edge of the web over the plate needles, just forward of the yarn car-

riers, or if the web is thin, the needles will push through it, by simply lifting the web up in front of the needles. The extra wide throat of the machine at the places ahead of the yarn carrier permits of this being easily done.

In starting the racking machine after a quarter runs off, it is necessary to see that the racking or shogging chains are in proper position to start a new garment.

The flyings of the yarn should be blown out of the machine occasionally. This may be easily done with a piece of pasteboard, or other like article used as a fan.

Cams. If there is any indication of breaking the shanks off the needles, after the machines have been running a short time, it is best to take the draw or knock-off cams out of the machine to see that they are smooth and free from any nicks or marks.

When the stitch cams or knock-off cams are ground, or a new one put into the machine, it is a good practice to see that the first corner is rounded a little and the balance sloped off after leaving the end wide enough to hold two needles at full length of the stitch. If more than two needles are held back, they may break holes in the web.

The *cams on the cam plate* or horizontal needles can be inspected by taking out the two screws which fasten the segments to the cam plate; the segment can then be slipped to the left by turning the machine by hand a short distance, holding the segment stationary; in returning the segment to place, drop it over the needles in its proper position, and slide it to the right, until the screw holes come into line, insert the screws and fasten down tightly.

The *knock-off cams* in the cylinder can be removed by taking out the large headed screw which acts as a stop to that cam when knitting the tuck stitch; the cam can then be removed and replaced in the same way. By pulling the knuckle pin, the ring can be moved to any position by hand. If after putting the machines together again, any drop stitches appear in the web, it may be found that the cylinder cam plug requires re-adjustment.

If the *geared ring* carrying the steels should get misplaced in taking a machine apart, it can be set into proper position by loosening the buttons on the outside of the cam plate, then lifting this plate out of mesh with the driving gear; turn the shaft backward or forward sufficiently to set the steels in their proper position.

When it is desired to make faced goods with one face of the fabric wool and the other or back of cotton, it is only necessary to thread the wool yarn into alternate carriers and the cotton yarn into the others.

When it is desired to make plated goods, with wool or silk surfaces and the middle or interior of the fabric of cotton, the wool threads should run through the quirl guides nearest the center of the machine near the carrier, and the cotton in the quirls next to the outside of the machine. Such plating can be done on the outside or inside surface of all tucked goods by threading alternate carriers with cotton, according to the side on which it is desired to show the wool. Threading the wool and cotton into all the carriers as above described to plate, will give both surfaces plated, either plain rib or tuck stitch.

FLAT OR STRAIGHT LATCH NEEDLE MACHINES, OR THE LAMB SYSTEM.

THE LAMB KNITTING MACHINE.

The machine illustrated at Fig. 98, is constructed upon the novel principle of employing two straight, parallel rows of needles sufficiently near each other to connect the two rows of knitting at either end, but far enough apart to allow the fabric to pass down between them as it is knitted.

Position of Needles. The two rows of needles are placed opposite each other, in grooves in a steel needle bed, the two sides of which slope from each other like the roof of a house, and are separated at the ridge, or center, where the needles form the stitches.

A *carriage* is propelled by a crank back and forth over the needle bed. This carriage contains, under each side, an arrangement of automatic cams, called a lock, (one for each row of needles) for operating the needles up and down in the grooves; and also carries a yarn guide for delivering the yarn from the bobbin into the hooks of the needles as they are moved up by the cams. As the carriage is driven over the needle bed, the needles are moved up, fed by the yarn, and drawn down almost simultaneously, all the needles forming stitches with one revolution of the crank.

The lock is so constructed that by adjusting a cam step, (this being possible without stopping the machine) the cam lock may be opened or closed, (but engages the needles only when open) in such a manner as to cause four different styles of fabric to be produced,

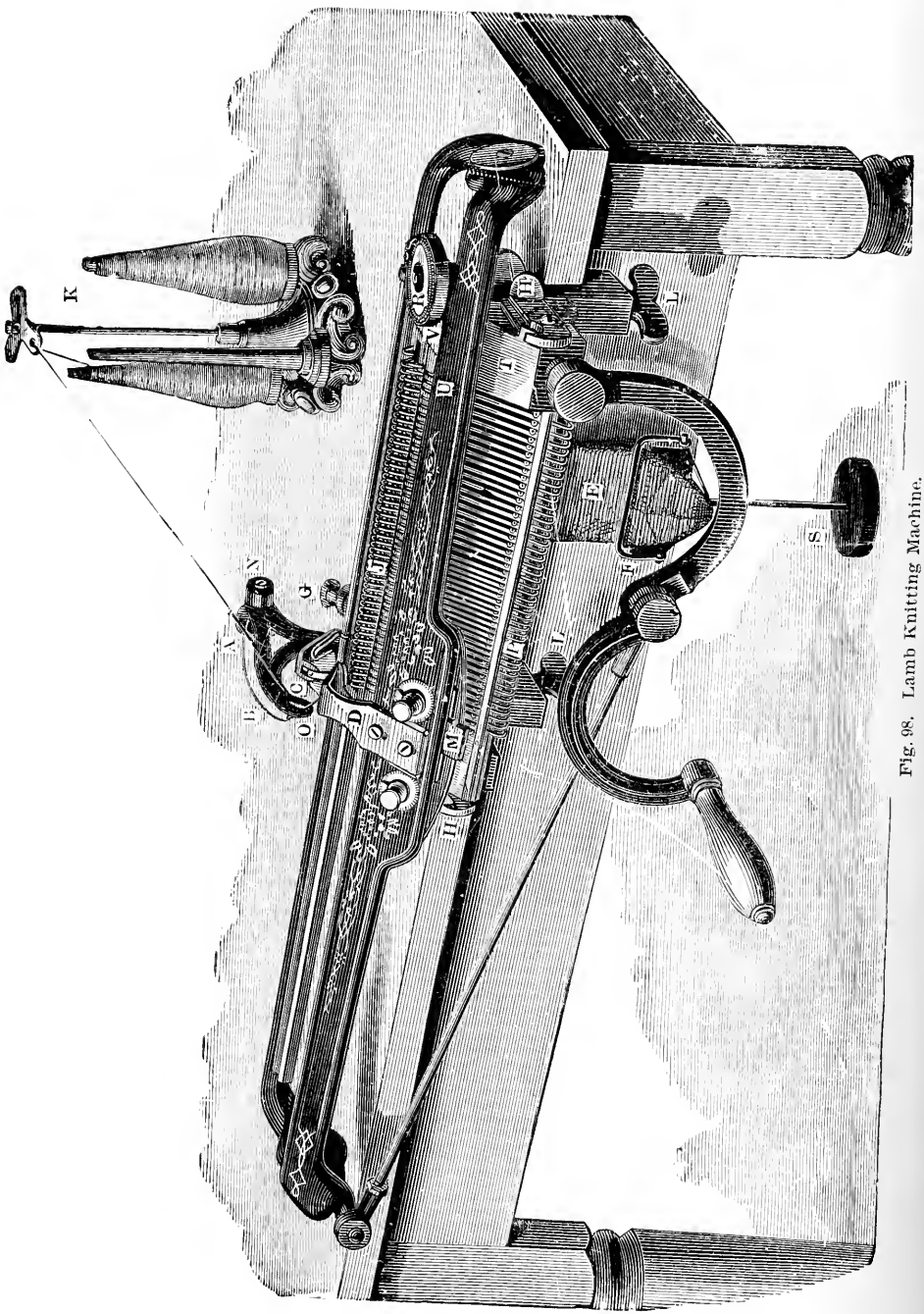


Fig. 98. Lamb Knitting Machine.

as follows: By operating continuously the back row of needles toward the right, and the front row toward the left, a *tubular or circular web* is produced. Operating both rows together in one direction and then one row in the other direction, will produce the *double flat web*, or *Afghan stitch*. Operating both rows together in both directions, produces the *ribbed or seamed flat web*, and operating forward and back each row alternately, connects the two rows of knitting at one end, leaving them open at the other, thereby forming the *wide flat web*.

In knitting any of the above webs, if every second, third or fourth needle, or a combination of them, in one or both rows is not used, other varieties of stitches can be formed, which make different styles of fabric.

Only those needles which are moved up within range of the cam are used. Any number of needles, in one or both rows, may be employed at the start, and the number be increased or diminished at any time, so any size of work, tubular or flat, and either single, double or ribbed, can be set up and widened or narrowed to any extent, producing such articles as union suits, fashioned hose, mittens, cardigan jackets, sweaters, etc. The two parallel rows of needles operating alternately, or crossing and uniting so as to form stitches on both sides of the fabric, is the distinguishing principle of the Lamb machine, in fact has come to be what is known as the *Lamb system*.

Referring to Fig. 98, the parts are as follows: A, tension nut; B, take-up spring; C, yarn guide; D, latch opener; E, work; F, buckle; G, hands, eccentric levers and thumb nuts; H, H, stops; J, jack wires or bitts; K, spool stand; L, thumb screws; M, slide plate; N, take-up stand; O, V-eyelet; P, needle stops; R, counter; S, weight hook; T, needle bed; U, carriage; V, caps.

Construction. As appears by examining the cut of the *short carriage machine*, Fig. 99,the bed frame consists of two parallel ways to which, at the desired angle and at the proper distance apart, is fitted the needle bed; at the right end of the frame are projections forming the bearings for the crank shaft. A connecting rod connects the crank with a projection of the carriage; by these means the carriage is propelled back and forth across the needle bed. On the back of the frame are projections for securing it to the bench or table. The term *bed* includes the two plates, (front and back) and the frame to which they are attached.

SECTION OF A FINISHING ROOM

Lawrence Mfg. Company.

quality of work that is made on the machine when making any of the ribbed stitches. If very coarse or loose work is called for, the throat must be wide; and if close, snappy or elastic work, the throat must be as close as will allow the work to pass down without hindrance. As for the sleeve of a jacket; the part from the shoulder to the cuff should be loose, while the cuff should be as close and snappy as possible. To do this to the best advantage, use the adjustable throat, which is easily changed from loose to close.

Locks. The cut *common locks*, Fig. 101, represents the under side of a short carriage showing common locks. It is the function of these locks to operate the needles up and down to form the tubular stitch.

The cut *automatic drop locks*, Fig. 102, represents the under side of a short carriage showing the automatic drop locks which do away with cam stops, and enable the operator to make the tuck or polka stitch on the inside of the needle hook, instead of on the outside, as done by the cardigan lock and all other locks making this and the cardigan stitch.

The *automatic tubular locks*, Fig. 103, are used for the same purpose as the common locks, but, being automatic, they do away with the cam stops and with them it is not necessary to run the carriage over the full length of the bed, but only far enough to pass all the needles in action.

The *cardigan lock* differs from the common lock chiefly in the arrangement of the wing cams, it being their function to draw down the needles. The wing cams (see B, Fig. 104) of the cardigan lock are made so that the needles can hold two stitches, when the carriage goes in one direction, and cast two and take one on in the other direction, and also form a shorter stitch. The wing cams of the common lock never take nor cast but one stitch at a time.

The *racking plates* are for the purpose of making oblique stitches in fancy patterns, or finishing for borders or edges.

Cam Stops. The Cam Stops H, H are (see C, Figs. 98 and 105) the four short bars at each corner of the needle bed that act on the slide plate M, (also B in Fig. 106) extending below the carriage, and open and shut the cams.

The Yarn Guide C delivers the yarn into the hooks of the needles, and must move at the same distance from each row, and as close as possible to them without touching.

Latch Openers. The steel plates fastened to the carriage, with upper ends hooked and having knife edges, are called the latch openers (See D, Fig. 98, also Fig. 105). Their function is to open or guard the latches of the needles, so as to admit the yarn into the hooks, and also to hold the latches down, out of the way of the yarn guide.

The Counter. The counter R (Fig. 98) is for the purpose of relieving the operator from counting while working. Turn the dial

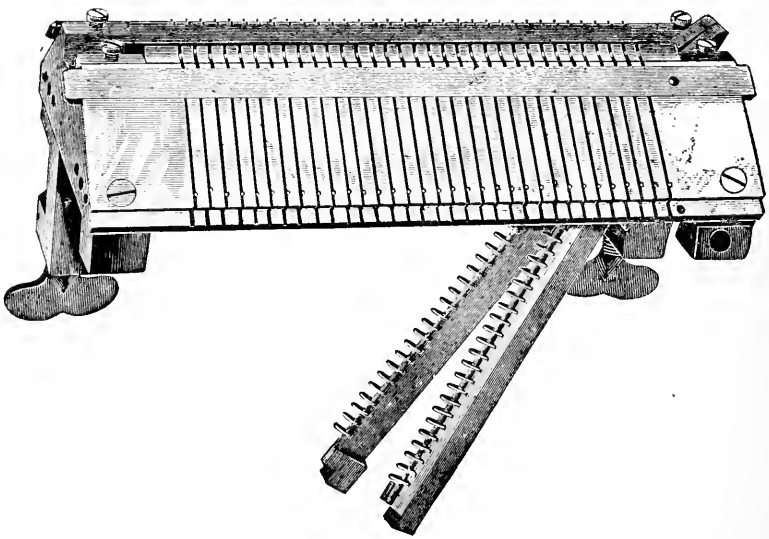


Fig. 100. 8-inch Bed, Showing Drop-Jack.

so that the pointer will rest on one hundred, and at every revolution of the crank, the dial will move one point, thus indicating each round knit.

Gibs. The needles are held in position by two flat slides with bevelled edges, called gibs, on which the carriage runs.

Weights. The work E is drawn down through the machine, between the jacks, by a weight on the weight hook S. As the object of weights on the fabric is to draw the loops off the needles as fast as made, it requires only just such an amount as will do this well. On coarse yarn, full width, four pounds is usually enough. With narrower width or finer yarn, three pounds; when operating less than thirty needles, use two pounds, etc. More weight is required in knitting

close, than in knitting loose. Cotton yarn requires more weight than woolen.

The Buckle. The buckle, F, which fastens on the fabric, is used only on long work; for all ordinary work, the combs are used.

Hands, Eccentric, (or Thumb) Nuts and Levers. The four hands, or pointers, on the carriage, are governed by the four thumb nuts 1 and 4 on the front side and 2 and 3 on the back side. The hands are connected with the wing cams. The wing cams draw the needles down, as the loops are formed, and determine the distance to be traversed by the needles. The farther the needle is drawn down, the longer the loop, and consequently the looser knit will be the fabric; the shorter the loops, the closer the fabric.

The Tension Take-up. If all the needles are in use, but little slack of the yarn will occur in any part of the traverse of the carriage; but if some of the middle needles are not in use, and the yarn is still being drawn out the full length of the needle bed, when the carriage moves one way, there will be a certain amount of slack yarn when it moves back; and the same thing will occur at the other end of the needle bed. The fewer the needles in use, the greater will be the length of the slack yarn.

As uniform tension is of great importance in a knitting machine, it is necessary to apply some device to all straight knitting machines, which will take up all slack yarn, and yet constantly exert a uniform tension on the thread of yarn that is passing into the needles. While the carriage is changing from one direction to the other, the yarn is held by the little weight (See Fig. 107) in the center of the cross piece, which drops upon it, as the take-up spring, changing from a horizontal position to perpendicular, releases the lever which holds the weight up while knitting. This applies more particularly to locks using cam stops than to drop locks.

ADJUSTING AND OPERATING.

Formation of Stitch and Operation of Needle. When knitting to the left, on the front row of circular work, the needles are moved up by the left side of the center cam, which is V shaped. Before they reach the highest point, the loops, one by one, slip down below the latches. On the right, the needles are drawn down again, at the same angle, by the wing cam. As the needles are drawn down, the yarn

is caught in the hooks, and the old loops pass under the latches, turning them over on the hooks. The needles continue downward until the loops slip over the ends, and the yarn is drawn through the old loops, forming a new set on the needles.

Position of the Needles. To place a needle in working position, move it upward until the hook is between the jack wires, or bitts J, Fig. 98. To move it out of position, draw it down half an inch, or as far as it will go. The needles should be moved up by the bow springs or needle stops P, at the bottom of the needle bed T, and drawn down by the shanks of the needles. The needles should be kept in working position or entirely drawn down, for if left half way between, the shanks are exposed to the cams, and the breakage of needles or needle bed will occur when the machine is set in motion.

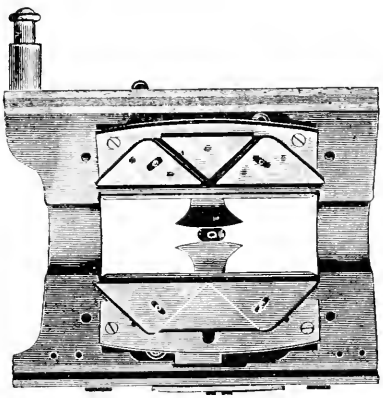


Fig. 101. Common Locks.

Adjusting the Tension. The tension nut A (Fig. 98) on the take-up stand, governs the wire take-up, B. To increase the tension turn the nut from you. To decrease it turn the nut toward you. In knitting stockings medium size, adjust the nut so that take-up wire stands about perpendicular. On double webs full width, diminish the tension so that the end of take-up wire is about *two inches* above the eye in the stand. The fewer needles in use, the more tension required, and coarse yarn requires more tension than fine yarn.

The yarn carrier traverses the full width of machine, but knitting is done at various widths. This occasions slack yarn, at either end, between the fabric and yarn guide. It requires only such a tension, in connection with take-up, as will draw in this slack and make the fabric perfect at the corners. The less tension used the easier the machine will operate.

To Tighten or Loosen the Stitch. The wing cams draw the needles down as the loops are formed and determine the distance to

be traversed by the needles. The farther the needle is drawn down, the longer it makes the loop and the looser will be the fabric. The hands G are attached to the wing cams. When the hand points to 1 at the top of the dial, the loops are shortest and the fabric closest. When the pointer is on the largest numeral, the loops will be longest and the fabric loosest.

TO SET UP THE WORK FOR A MITTEN.

Put up twenty-four needles (on each side), and draw down every third needle, commencing with the second from the end, then fasten the upright rod into the base of the spool-stand, so that each hole in the top plate comes directly above the wire post in the base. Place a spool of yarn on one of these posts, and draw the end of the yarn through the hole in the top plate directly above it.

Place the spool-stand K back of the needle bed with the spool to be used facing the machine. Have the crank at the left hand and move out right hand cam stop H on back side. Turn the crank to the right. Pass the yarn through the wire eye on top of take-up stand N, then through the V shaped wire O or hole in front end of the take-up stand N, and down through yarn guide C, dropping the end down between jacks J about six inches. Turn crank to the left and put in right hand stop, back-side. Both rows of needles have been moved up and taken the yarn, drawing it down in a sort of network. Draw the wire out of the comb Y, (Fig. 109) and push the teeth up through the network from below, and then run the wire into the teeth again over the network. Attach to this comb a weight stand and a two pound weight. Turn the tension nut A back a trifle more than a quarter of a revolution, so that the take-up wire B stands about perpendicular, or leans backward a little. Now spring down the take-up wire B and hook it on the yarn between the guide C and the take-up stand, then knit eighteen times round.

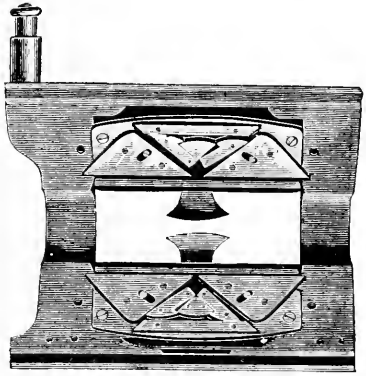


Fig. 102. Automatic Drop Locks.

Push up the needles drawn down and with the work hook (Fig. 109) pick up the last stitches or loops cast off the needles next to the ones pushed up, and put the loops on the empty needles. Knit four rounds, then widen for thumb as follows: Push up a needle at right hand on both front and back side and with a three point narrowing comb (W, Fig. 109) take the stitches on the three outside needles and put them on what are now the three outside needles including the needle just pushed up. This leaves the fourth needle empty. With the work hook pick up the last loop cast off of the fifth needle and put it on the fourth. Knit three round and widen again and so continue to widen until seven stitches are taken on each side. Use three point comb for widening the first three needles or for three stitches or less, then use four, five, and six, knitting three rounds between each. After the last widening knit six times round, then throw off these stitches which have been widened for the thumb on thumb combs X (Fig. 109) and draw the empty needles down out of working position and knit thirty rounds, then narrow as follows: Leave five stitches at one end, and with a five point narrowing comb transfer the next five stitches one needle toward the center; then transfer the five stitches, lift at the end two needles toward the center, and draw down out of operation the empty needles thus left. Repeat this process at the other three corners of the web. Knit four rounds. Leave four stitches at one end and with the next size comb, four points; transfer in the same manner as before. Knit three rounds. Leave three stitches at one end, and with next size comb, three points, transfer as before. Knit two rounds. Take three stitches from end, transfer one toward center; then take the outside stitch and transfer one toward center. This being repeated at each corner will leave all the needles with two stitches on them. Knit two rounds and take the work from the machine.

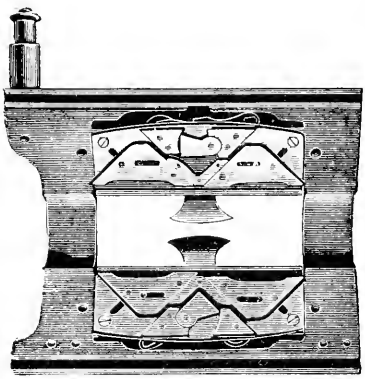


Fig. 103. Automatic Tubular Locks.

To Knit the Thumb. Drop the jack J and pick the stitches which were thrown off after widening, into the machine; seven on each side. Make two new stitches by taking two loops from the hand, thus making sixteen stitches in all; then knit eighteen times round and narrow off as follows: Narrow every third stitch and knit three times round, then every second stitch and knit twice round. Take the work from the machine, ravel once round, fasten the ends, cut open the wrist and crochet off, or when knitting the wrist knit it long enough to fold inside, making it double thickness.

Table of Sizes for Mittens.

Stitches.	Rounds for Wrist.	Stitches to Widen for Thumb.	Rounds for Hand.	Stitches for Thumb.	Rounds for Thumb.
21	16	6	25	7	16
24	18	7	30	8	18
27	20	8	35	9	20
30	20	9	40	10	22

TO KNIT GLOVES.

Put up twenty-four needles (on each side;) draw down every third needle, commencing with the second from the end. Set up the work and knit eighteen times round. Push up the needles drawn down and put a loop on each needle, the same as in widening. Knit twice round, then widen for thumb as follows: Push up a needle at right hand on both front and back side and put a loop on each as in widening by hand. Knit four rounds, then push up two more needles at right hand and with transfer comb take a stitch from the needles previously widened and put them on these needles. Knit four rounds and widen again, this time transfer two stitches; so continue to widen until you have seven stitches on each side; use 3 comb for three stitches or less, then use 4, 5 and 6, knitting four rounds between each, after the last widening. Knit around six times, then throw off five of these stitches on each side which have been widened for thumb; knit sixteen times round, then at left hand throw off three stitches on each side; knit two rounds, and throw off next five stitches on each side; knit two rounds, throw off seven on each side; this leaves eleven stitches on each side; knit thirty rounds and narrow every third stitch, knit two more and narrow every second stitch; knit two rounds and take from the machine.

To make the second finger, have the crank at right hand, then

with thumb at right, pick the next twelve stitches (six on each side) into the machine, and ravel once round; cut thread near the finger and pick out ten stitches, five each side of opening, separating finger from hand front side; pick these into machine beside those already in, putting those from finger on back side, and those from hand on front side; knit thirty-five rounds and narrow as before. Repeat for third and fourth fingers, using ten stitches and thirty rounds for third, and nine stitches and twenty-two rounds for fourth.

For thumb, ravel once round, cut the thread and pick each way, both front and back, until there are ten in all picked out, five on hand, and five on thumb; pick into machine, knit twenty-two rounds and narrow off.

For *left hand* glove knit the same until you pick in stitches for second finger, then with thumb at left hand, proceed as directed above for knitting fingers.

Table of Sizes for Gloves.

Stitches for Wrist.	Rounds for Wrist.	Stitches to Widen for Thumb.	Stitches to Throw off for Thumb.	Rounds for Hand.	Stitches to Throw off for 4th Finger.	Stitches to Throw off for 3d Finger.	Stitches to Throw off for 2nd Finger.	Stitches for 1st Finger.	Rounds for 1st Finger.	Stitches for 2nd Finger.	Rounds for 2nd Finger.	Stitches for 3d Finger.	Rounds for 3d Finger.	Stitches for 4th Finger.	Rounds for 4th Finger.	Stitches for Thumb.	Rounds for Thumb.
24	16	7	5	16	3	5	7	11	30	12	35	10	30	8	22	10	22
27	18	8	6	18	4	6	7	12	33	12	38	11	32	9	24	11	24
30	20	9	7	20	5	7	8	13	34	13	40	12	35	10	26	12	28
33	20	10	8	22	6	7	9	13	38	14	44	12	38	11	28	13	30
36	22	11	9	24	6	8	10	14	40	15	48	13	40	11	30	14	33

KNITTING A SOCK COMPLETE.

Put up thirty needles on the front row and the same on the back, then draw down every third needle put up, beginning with the second needle from the end. Set up the work as usual, and attach a two-pound weight. Before attaching the take-up spring, bind off the top as follows: With the crank at the left, push up the back needles, on which the work is set, as far as they will go; draw off the slack thread below the yarn guide about ten inches; and beginning at left wind this yarn (next to needles) as loosely as possible around each needle moved up. Pass the yarn under each needle and wind it around the hook to the left, sliding the needles down with the left thumb as fast as they are wound, far enough to cast off the stitches; then bind the front row in the same manner, beginning at the right hand. Adjust the take-up spring to take up the slack, and hook it on the yarn between

the take-up and the yarn-guide; knit twenty-five rounds and then put up the needles drawn down (every third), and knit one round.

For length of leg, knit seventy rounds. Have crank at left.

For the heel, set hand 1 at "*close*", and 3 same as 2. Put out both right hand cam-stops. Knit two rounds, at the same time drawing down on the back part of the fabric with the left hand. Now put the large triangular wire over the work, draw it down well between the rows of knitting, and attach to it a weight-stand and one-pound weight. Remove the two-pound weight from the set-up comb, leaving the weight-stand only.

For the length of heel, knit ten rounds, or one-third as many as there are needles in use on front side, stopping with crank at left. To prevent the work from rising up on the back needles while knitting

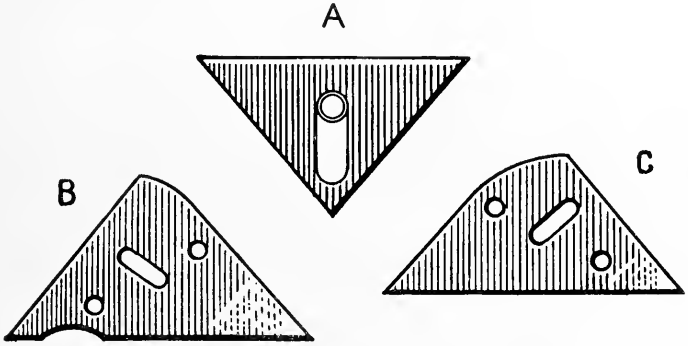


Fig. 104. Cams. A, "V" Cam. B, Wing Cam. C, Cardigan Cam for Common Lock.

the length of the heel, draw down on back part of it with the left hand.

Then lessen the weight on back, leaving only the weight-stand. Next take a worsted needle, threaded with a piece of yarn, and pass the needle up from below through the 11th stitch from the right. Tie this yarn underneath, and remove the weight-stand from the set-up comb on front, and hook it upon this yarn. Add to this a one-pound weight. With crank at left, push up, as far as they will go, 10 needles at right hand, back row. Transfer the stitch from 10th needle to 11th, the next needle to the left. Slide the other 9 needles partially down; not quite far enough to cast off stitches.

Place one of the small combs on the front side, opposite these 9 needles, and with the work-hook transfer the stitches from these nee-

dles to the hooks of the comb. Draw the empty needles down out of working position. Turn crank to right. Push up as far as they will go the 10 needles at left hand, back row, and transfer the stitch from the 10th needle to the 11th. Place the other small comb opposite these 9 needles, and transfer the stitches from them to the comb, drawing down the empty needles as before.

To knit the cap for the heel on the remaining 10 needles in use, the crank should be held at the lowest point and moved back and forth only far enough to form each end stitch. Every time the crank is moved to the left, transfer a stitch from the right hand comb to the 11th

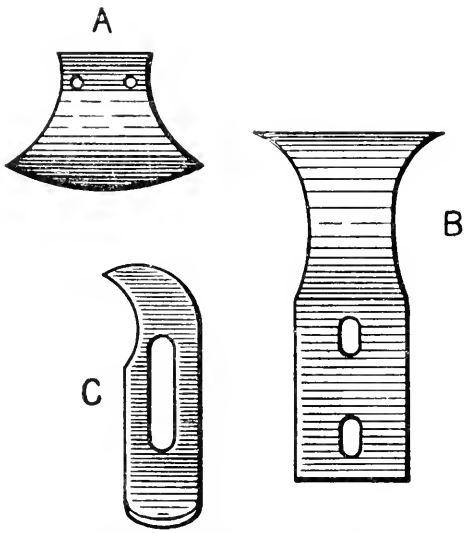


Fig. 105. Cam Stop C, Front Latch Openers B, and Back Latch Openers A.

or end needle; and every time the crank is moved to the right, transfer a stitch at left in the same way. With the crank at the left, transfer the last stitch from each comb, both at once. (In transferring stitches, be careful to carry the stitch straight across from the comb into the hook of the needle, without turning or twisting the stitch.) Remove the small combs and triangular wires. Put in both right hand stops, and replace the hands, setting 3 at "*close*" and 1 same as 2. Remove the weight from the back, leaving the weight-stand.

Now put up at right hand the 10 needles drawn down, and one

extra needle on front and back. With the flat end of work-hook, push up, from underneath, the selvedge of the heel, on a level with the needles, and pick on to the needles the 10 short loops of the selvedge made in knitting the heel. Draw down on the back part of fabric lightly with left hand, and turn crank to the right. Put up at left the 10 needles drawn down, and one extra needle on front and back; then pick on to them the 10 short loops of selvedge. Attach weight-stand and one-pound weight to the set-up comb on front. Set hand 2 at "*close*," turn crank to left, and then set hand 2 the same as hand 1.

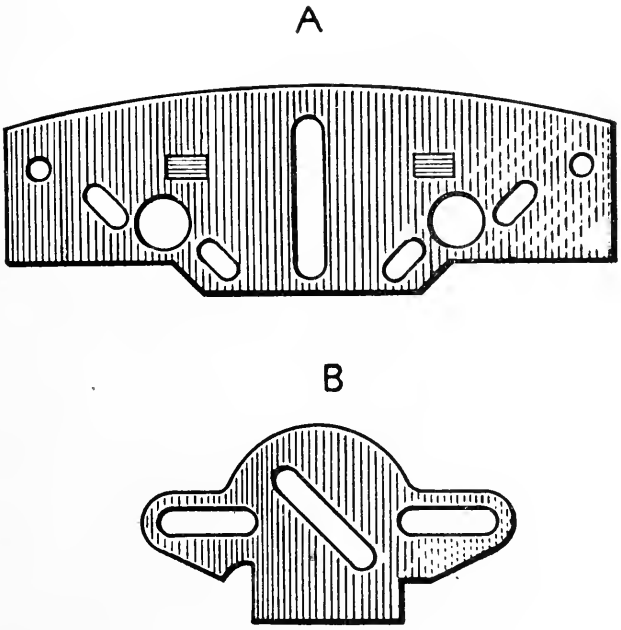


Fig. 106. Lock Plate A, Slide Plate B.

Replace the one-pound weight on back. Knit five rounds, drawing down on back side of fabric with left hand.

For the gore, narrow four needles, one at each of the four corners of the fabric, as follows: Narrow one at right and one at left, and knit three rounds. Then narrow one at right and one at left of the other two corners. (In narrowing on front, carry the stitch across to the end back needle; and in narrowing on back, carry the stitch across to the front end needle. It will be observed that the needles in the

two rows do not come exactly opposite each other at the ends. Always narrow the outside needle.)

For the length of foot, knit forty-five rounds, then narrow off the toe by narrowing one needle at every half turn of the crank until only 10 needles remain on each side. Knit two rounds and run off the work; ravel one round and with a worsted needle fasten the end stitches with the button-hole stitch, or over-and-over stitch. Pick the long stitches out of top of leg with the work-hook, beginning at the corner where the long yarn is; or cut the long stitches at the top and pick out the cut stitches.

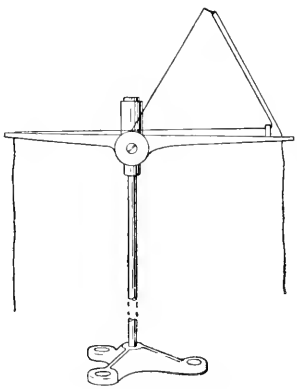


Fig. 107. Tension Take-up.

To Knit Larger Sizes, set up 33 or 36 needles on each side; or to knit any desired size, reverse the order of the rule in the Table of Sizes given on Page 183, and knit ten rounds less in the foot.

To Knit a Stocking Narrowed in the Back, proceed as follows: Push up all the needles in machine. Set up the work and knit one hundred and thirty rounds, then with crank at left hand, narrow two stitches at right, one on front and one on back side. Knit six rounds, and narrow in the same manner, and so continue to narrow until but 36 stitches are left on each side. Knit fifty rounds and take the work from the machine.

Now pick the work into the machine in such a manner that the narrowing in back will be in line with the center of the back row of needles, and knit heel and foot in accordance with the rule given above.

To Use the Narrowing Comb: Put the eyes of the comb into the hooks of needles and with the comb draw the needles up until the stitches pass back of the latches; then push down until the stitches cast on to the comb, and transfer them to the needles as desired.

To Narrow Off Toe With Narrowing Comb. Leave six stitches at one end and with comb 6 transfer the next six stitches one needle toward the center; then transfer the six stitches left at the end two needles toward the center, and draw down out of operation the two empty needles thus left.

Repeat this process at the other three corners of the work, and knit five rounds. Leave five stitches at one end, and with the next size comb (5) transfer in the same manner as before, and knit four rounds. Leave four stitches at one end, and with the next size comb (4) transfer in same manner and knit three rounds. Leave three stitches at one end, and with the next size comb (3) transfer in the same manner and knit two rounds. Leave two stitches at one end, and with comb 3 transfer in the same manner and knit two rounds. Leave one stitch at one end, and with comb 3 transfer in the same manner and knit two rounds. Now transfer so as to bring two stitches on each needle. Knit two rounds and run off the work.

Tables of Sizes

MEN'S SOCKS

Size of Shoe	No. of needles to set up on each side	No. of rounds for rib	No. of rounds for leg	No. of rounds for ankle	No. of rounds for heel	No. of rounds for foot
No. 5	34	30	75	30	12	45
No. 6	36	30	80	30	12	50
No. 7	36	35	85	30	12	55
No. 8	38	35	90	30	12	60
No. 9	39	40	95	30	12	65

LADIES' STOCKINGS

Size of shoe	No. of needles to set up on each side	No. of rounds for rib.	No. of rounds for top of stocking	No. of rounds for ankle	No. of rounds for heel	No. of rounds for foot
No. 3	38	——	110	32	12	40
No. 4	40	——	110	34	12	45
No. 5	42	——	120	36	14	50
No. 6	44	——	120	36	14	55
No. 7	46	——	130	38	15	60
No. 8	48	——	130	38	16	65

BOYS' AND MISSES' STOCKINGS

Size of shoe	No. of needles to set up on each side	No. of rounds for top of stocking	No. of rounds for ankle	No. of rounds for heel	No. of rounds for foot
No. 12	38	85	30	12	36
No. 13	40	85	35	12	38
No. 1	42	85	35	12	40
No. 2	44	90	40	12	42

To Ravel the Work in the Machine. Ravel out the loops by pulling the loose yarn straight up over the ends of the needles. If holes appear or the yarn breaks the loops that run off, put on the needles, and ravel down the work to where it is perfect.

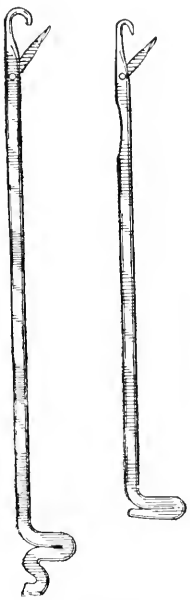


Fig. 108.
Lamb Needles.

To Remove a Needle from the Machine. Take off the caps V at either end of the needle bed that hold down the carriage U, and remove the carriage. When removing the rod be careful not to let the block slip off the rod and not to turn the rod end for end. The hollow side of the block is the front and the pin on top of the block fits into a hole in the lever that operates the yarn guide C. See that this is adjusted properly and operates freely before fastening the caps V.

An arrow on each gib points the direction in which to move the gib in order to take it out. Push the gib out in the direction indicated by the arrow, until the end passes the needle to be removed; then draw the needle out and put in another. See that the new needle works freely after the gib is replaced. The caps should be replaced, putting each in its own place.

When any of the latches fail to open, press down on the latch opener with the hand, and move the crank to operate the needles once or twice before setting up the work. When the work rises up on the

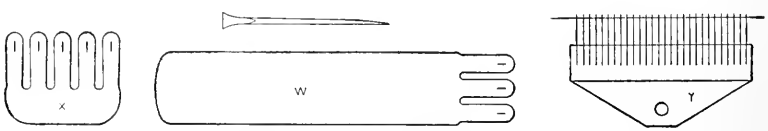


Fig. 109. Combs and Work Hook.

needles add more weight. When the needles move up in knitting, if the loops fail to slip down back of the latch, knit looser.

When the needles take the yarn and retain the loops without knitting push the needles up until the loops slip back of the latches, then drop the yarn into the hooks and draw the needles down, knitting off the old loops. After the loops are formed, if they fail to cast off

the ends of the needles, adjust the machine to knit looser. If the outside needle drops stitches, or long loops are made at the corners, use more tension. If stitches drop, along in the center of the fabric, see if the yarn has caught and broken, and if the yarn guide runs in the right position, *i. e.*, the same distance from each row of needles. If one particular needle drops stitches, bend upward the upper end of the needle. If the machine suddenly works hard, see if the yarn draws freely from the spool.

If one row of needles ceases to operate while knitting or both rows operate when not desired, arrange the stops H properly. If a needle catches or hits in operating, making a snapping or clicking

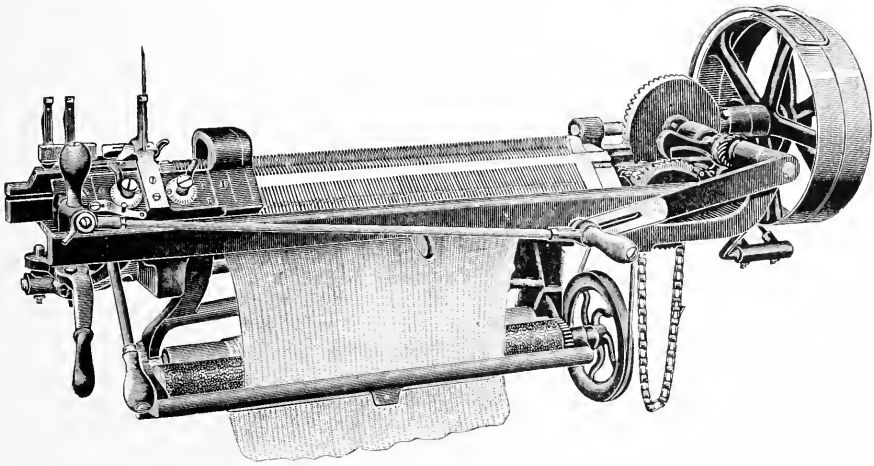
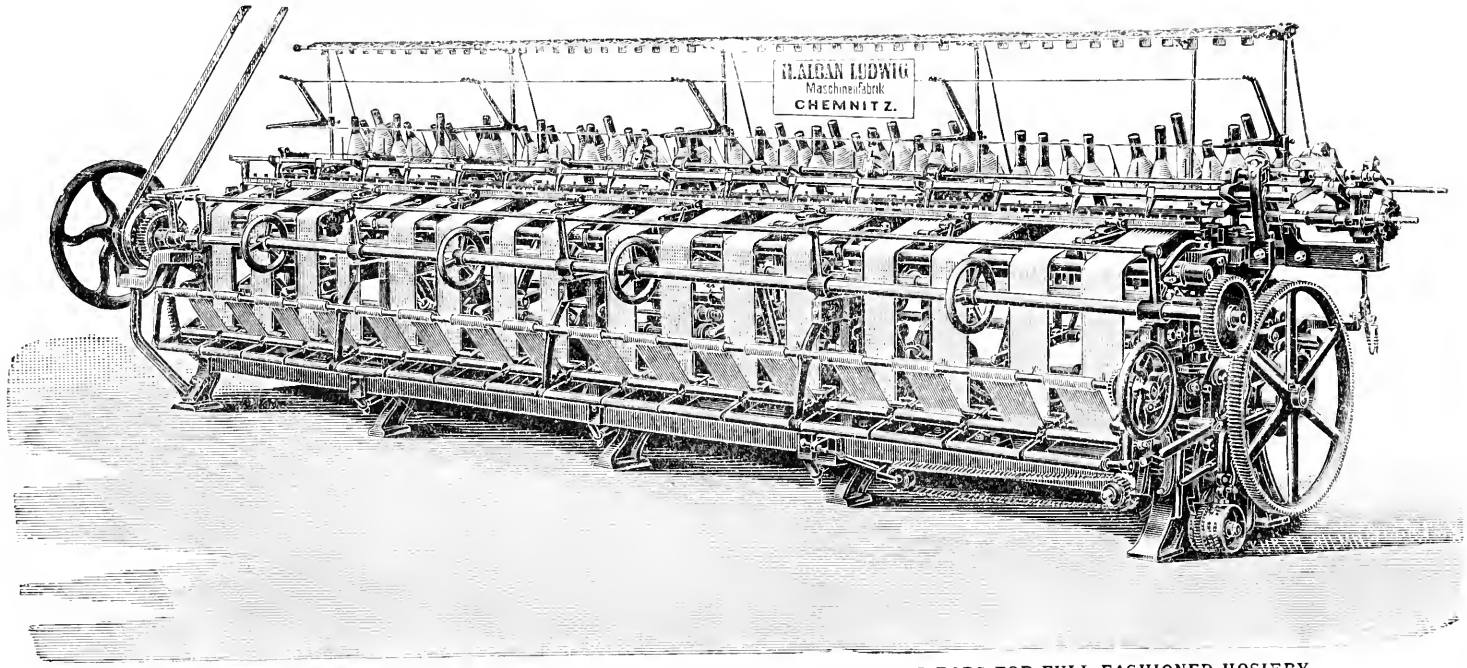


Fig. 110. Lamb Bench Bracket Power Machine.

sound, see that all the needles are in place; either in working position or drawn clear down. If the needles are all right, see that the slide plates M, just below the latch openers, are adjusted to require considerable force to shift by hand. If they are allowed to work loose the A shaped cam falls in the way of the needles. If one is found loose, tighten the large screw that holds the spring washer to the A shaped cam, and see that the lock spring is in its place on the slide. If this does not remedy the difficulty, turn the crank to the extreme right and see whether the slide plates can be moved farther to the left after the stops have shifted them; turn the crank to the left and see if the slide plates can be moved to the right after being moved by the

stops. If any one of the stops H, fail to shift the slide plate M as far as it will go, screw that stop closer to the needle bed or bend the point in a trifle.

If the latches of the needles become bent by accident or otherwise, straighten them with the fingers.



FLAT RIB KNITTING MACHINE ON COTTON PATENT, 16 SECTIONS MAKING RIB TOPS FOR FULL FASHIONED HOSIERY

Grosser Knitting Machine Co.

KNITTING.

PART IV.

HOSIERY KNITTING

The class of machines now commonly employed for knitting stockings and socks is of the Circular Latch Needle type, though in at least one instance spring needles are employed in a Circular Machine. In other instances spring needles are used in the Straight Rotary Machines for making full fashioned hosiery on what is known as "Cotton's System." This method will be explained in a subsequent chapter. As the Circular Latch Needle Machines are generally used in the United States, this type will be explained first.

CIRCULAR LATCH NEEDLE KNITTING MACHINES

There are several styles and classes of Circular Latch Needle frames which may be classed as follows: *Hand Machines, Semi-Automatics, Three-Fourths Automatics, Seven-Eighths Automatics, Fifteen-Sixteenths Automatics,* and *Full Automatics.* The progressive order impresses one with the splendid mental resources and superior mechanical ability of the builders of Circular Latch Needle Stocking Machines.

In knitting stockings a number of difficult propositions present themselves, of which the most important is the operation of shaping the stocking to the leg and foot of the wearer. Another difficult operation consists of splicing those portions of the stocking which are subjected to the most wear; while the ornamentation of the article, either by the use of a plurality of threads of different colors to produce vertical or horizontal stripes or figures, or by a variation in the character of the stitch to produce what is technically known as lace or open work, represents a third difficult operation. To produce these various effects automatically, devices have been perfected to accomplish the following purposes:

(1). Change the length of the stitches

(2). Stop the machine or change its motion from rotary to reciprocating, without stopping.

(3). Put up out of action about one-half the needles.

(4) Put up out of action *one* needle of those remaining in action at each course knit.

(5) Restore these needles successively to action.

(6). Restore the instep needles to action.

(7). Change the motion from reciprocating to rotary again.

These changes are accomplished in various automatic ways by the several different builders, but all depend upon a pattern chain or wheel, which measures the length of fabric knit, and at predetermined periods, shifts the motion-changing and needle-cam devices to effect the required result.

In the simple Hand Machines these various operations are effected by the operator manipulating the levers etc., as required to accomplish the desired result. One by one, almost, each operation has been made to accomplish the result automatically, until now we have the Full Automatic.

Full Automatics may run continuously on women's goods, passing from stocking to stocking without assistance from the operator. In making half-hose or socks the machines are automatic to a like degree, except that they must be stopped at the end of each article, so that another cylinder may be introduced with the rib-top on the needles; or a transferring device may be used for putting the rib top or hose leg on the needles, which in the latter case does not necessitate removing the cylinder from the machine.

Originally, machine-made seamless hosiery was made on hand machines wherein each needle for the formation of the heel and toe had to be manipulated by hand, and all other changes effected by the crudest means.

As the Hand Machine is the simplest form of machine knitting, more easily understood and plainly presenting operations, performed by hand, that the Automatics perform by mechanism, it may be well to take it up first, for it treats the fundamental principles simply and clearly. The results obtained on the several classes of Circular Latch Needle frames are practically the same, but the mechanical arrangements have grown more complex as devices have been perfected for performing automatically the various operations of shaping hosiery.

HAND MACHINES

The stitch in plain machine knitting is exactly the same as made in plain hand knitting, though more perfect and even. The number of stitches required to be put on the needles, in setting up the work, depends upon the size of the yarn and the size of the sock or stocking desired. A large size stocking requires more stitches than a small one,

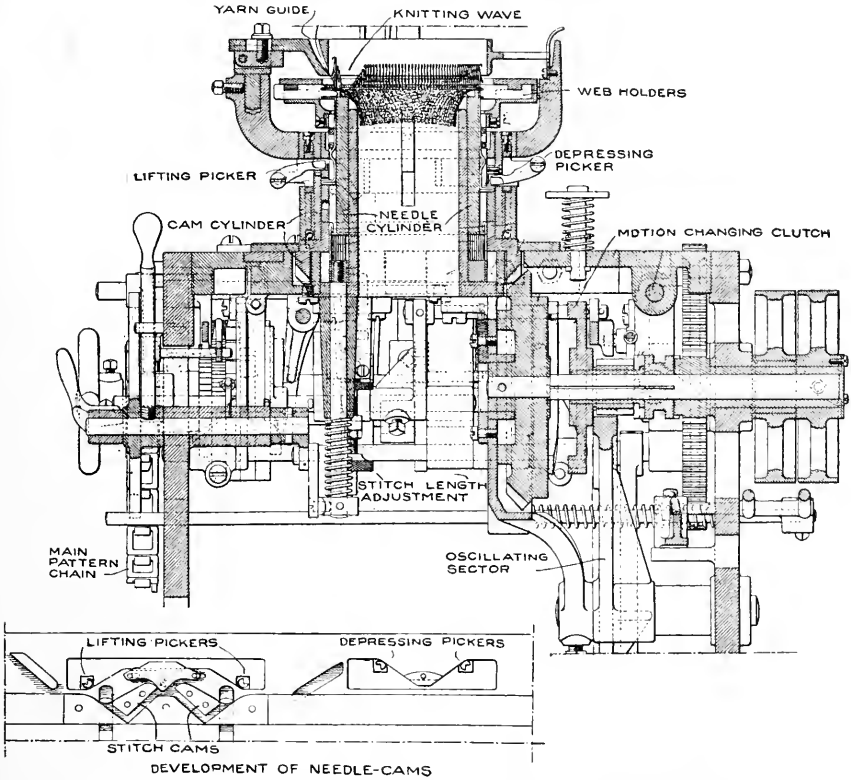


Fig. 111. Sectional View of Typical "Full Automatic" Circular Latch Needle Fashioning Machine.

and fine yarn requires more stitches and finer needles than are required by coarse yarn. It is for this reason that needle cylinders are required to contain a different number of slots, or places for needles, to suit different sizes or grades of yarn, and is also the reason why they are required to be made of different diameters to make the various sizes of hosiery. The number of slots may be different in cylinders of the same size, according to the requirements of the work.

There are three conditions that will change the size of the hose; *first*, the number of needles in the cylinder; *second*, the length of the stitch; and *third*, the size of the yarn.

Fine yarn knit on a cylinder containing 60 needles will produce a small size stocking, but if knit on a cylinder containing 100 needles will make full size hose. The tighter the stitch the smaller the tube, or web, in diameter; the looser the stitch the larger the tube. The coarser the yarn used the larger will be the tube produced with a given number of needles, and the finer the yarn the smaller the web or tube produced. For example, the coarse cylinder will make a child's stocking with a fine yarn knit with a short stitch. Seamed work is always smaller in diameter than where the full number of needles in the cylinder are employed. With every other needle out a very small tube can be knit.

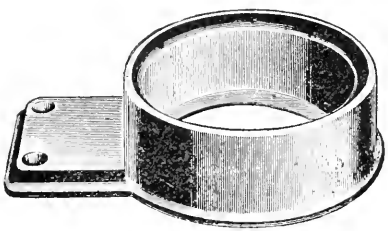


Fig. 112. Transfer Cup.

Operation. These machines are operated entirely by hand during the circular and also during the reciprocating movement required to make the heel and toe, the needle being raised and lowered by hand, by means of a working-hook (A in Fig. 114). The work is held down by means of weights.

In starting the work, the knitting is commenced at the top of the stocking and set up with a selvedge, the same as if knit by hand. For half-hose, or socks, the top may be ribbed or seamed as far as required by removing every second, third, or fourth needle, and then changed to plain knitting by replacing the needles removed for that purpose. Narrowing, for shaping the leg of a stocking, may be done with the stitch regulator without stopping the machine. The heel is knit at the proper place by knitting backward and forward, and may be made double thickness if desired. Knitting the foot is then continued and the toe finished on the machine, except joining a few stitches at the toe, which is done by hand with a finished needle after the stocking is taken from the machine. The machine is usually fastened to the table or bench by means of thumb screws.

Fig. 115 is an illustration of the Branson Hand-Knitting Machine. The parts are designated in this illustration as follows: A is the cam

cylinder; B, needle cylinder; C, yarn guide; D, yarn carrier; G, stitch regulating lever; and H, take-up spring.

The Yarn Guide, C, guides the yarn from the bobbin to the yarn carrier D. The three arms on the back part of the machine are used when knitting different colors of yarn, or when knitting double or triple threads.

The Take-Up Spring, H, is used only when knitting flat web, the heel and toe, or any tubular work where *some* of the needles are taken out, and where a close stitch is required. The spring is adjustable at the point where it is attached to the yarn guide and may be raised or lowered as more or less tension is required for knitting light or heavy yarns. In knitting the heel or toe it should draw the yarn close around the lifted needles. When in use it is to be hooked under the yarn between the tension ring and the slot in the end of the guide.

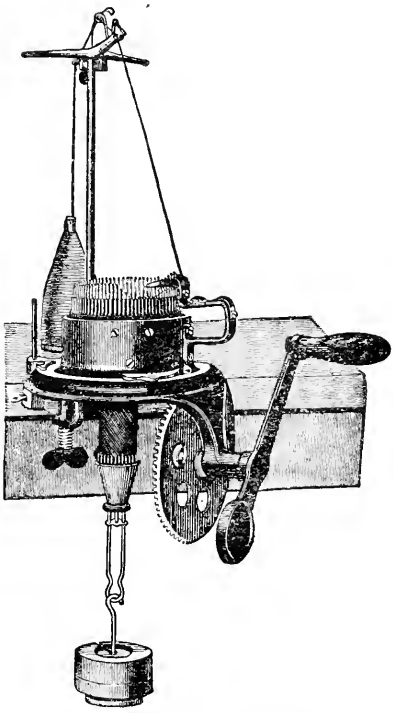


Fig. 113. Type of Hand Machine.

The Yarn Carrier, D, carries the yarn to the needles. It is fastened to the cam cylinder with screws, and must be removed before changing cylinders. When returned to place it should be pressed down on the screws as far as possible. When threading the yarn carrier, always pass the yarn through both holes, from the outside to the inside.

The Cams M and O (Fig. 116) are stationary, and act simply as guides to guide the needles to the stitch cams N and L. The stitch cams perform the entire operation of knitting backwards and forwards; they swing loosely on pins provided for that purpose at their upper ends and swing back, as shown by L, when the needles pass under them to form the stitch. They are in position, as shown by N, when the need-

les pass over them to free the latches. The machine is turned until the needles are all passed out from under the cam in either direction when the cams drop automatically, bridging the opening, and causing the needles to pass up over the cam on that side and down under the cam on the opposite side, thus forming stitches. If by any means the cams get in a position so that the needles pass down under both of them and the needles are not lifted up to free the latches, by lifting up several of the needles above the cams and turning the machine past these lifted needles, the cam will drop down and the needles pass up over it. Then push down the lifted needles.

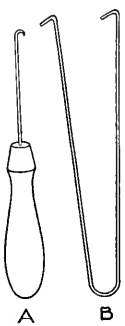


Fig. 114.
Work Hook and Heel Hook.

To Regulate the Stitch. Draw the stitch regulator, G, to the front of the machine to lengthen the stitch, and push it toward the back of the machine to shorten the stitch. In ordinary knitting the stitches should be long enough to easily draw down to the needle cylinder, for tight or close knitting makes the web hard and inelastic. When the stitch is too short it will not pass down over the latch of the needle freely unless considerable weight is applied. When the needles do not knit but the yarn lies in front of them, not knit in, the difficulty usually is in having the stitch too short.

The weights hold the stitches down so that the needles may pass up through them as they are raised up just behind the yarn carrier. Before any knitting is done, the needles must be raised up high enough to allow the stitches to get below the latch of the needles. The weight does not affect the length of the stitch, but only holds it down. If the stitch is of the right length, and the proper amount of weight is used there will be no difficulty with the needles, as they are self-acting.

Needle Cylinders are made to contain different numbers of slots for needles to suit different sizes and kinds of yarn, and to make different sizes of hosiery, as in the instance cited where fine yarn knit on a cylinder containing 60 needles will make small hose; but knit on an 84 or 100 needle cylinder, will make full sizes.

Fig. 118 represents needle cylinders, without needles, for each of the four different size heads used in this machine. The number of slots and needles a cylinder contains represents the number of stitches that will be made each round, while knitting with that cylinder in the

machine. The number of slots in a cylinder does not necessarily increase or diminish the size of that cylinder, but only places the needles nearer together or farther apart, as fine or coarse work is desired. Cylinders are commonly cut for any number of needles desired up to 176 slots, and sometimes finer, with inserted sheet steel walls.

Cylinders are changed by removing the yarn carrier D, and either

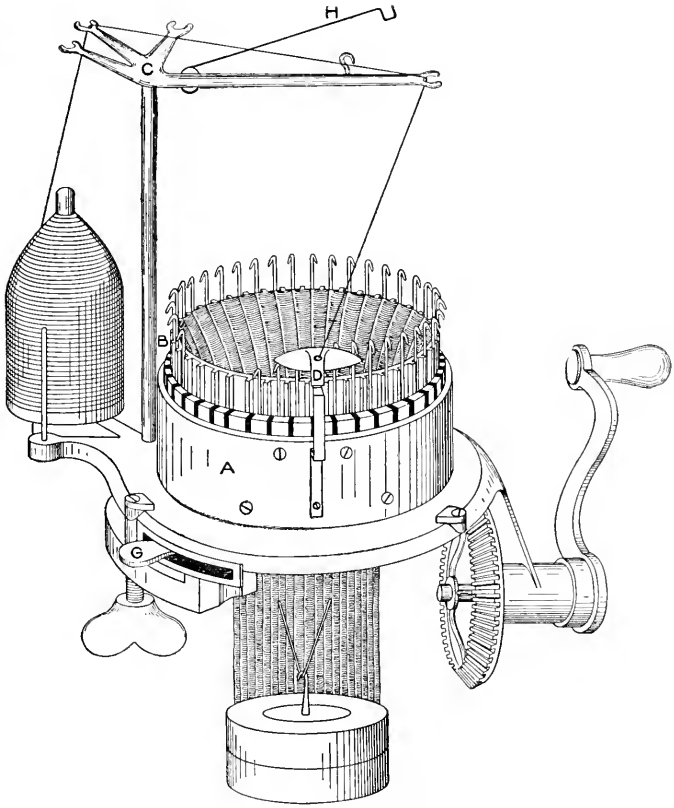


Fig. 115. Branson Hand Machine.

lifting up enough needles to allow the cams to pass under and be free of needles, or removing them and lifting the cylinders out of the cam cylinders. In putting another cylinder in place, put the slot, in the under edge of the cylinder, on the stud in the back of the bed plate, and then secure the yarn carrier in its proper place.

A combination is effected in these machines in such manner that

the bed (Fig. 119) or running gear of the machine accommodates the different size heads and their cylinders, the gear rim of the head being always the same size, the difference being in the size of the cup of the head for holding the needle cylinders. This is shown very clearly in Fig. 120.

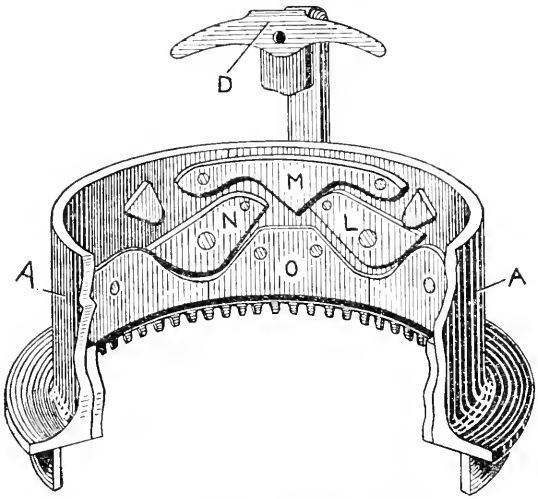


Fig. 116. Cam Cylinder Showing Cams.

Needles. There are three sizes of needles in general use in these machines, called 12 gauge, 18 gauge, and 24 gauge. They are used in knitting different grades of yarn so as to form large or small stitches. For coarse yarn such as is generally knit on the 60 and 70 needle cylinders, the 12 gauge needle is used. For finer yarns the 18 gauge needle in the 84 cylinder, and the 24 gauge in the 100 needle cylinder are used. The 18 and 24 gauge needles are also used in knitting cotton; the 18 gauge in the 84 needle cylinder, and the 24 gauge in the 100 needle cylinder.

The regular standard of gauges adopted by the builders of this machine is as follows:

12	gauge	needles	for	cylinders	having	four to six	needles	to	the	inch
18	"	"	"	"	"	six to eight	"	"	"	"
24	"	"	"	"	"	eight to twelve	"	"	"	"
36	"	"	"	"	"	twelve to fifteen	"	"	"	"
42	"	"	"	"	"	finer than fifteen	"	"	"	"

Sizes of Yarns Used in Different Cylinders.

A 56 needle cylinder will make a 5 inch child's stocking. Use 64

needle cylinder for 6 inch stocking, 72 needle cylinder for 7 inch stocking and 80 needle cylinder for 8 inch stocking.

Two-ply 18 or two-ply 20 cut woolen yarn makes a good hose for children.

Two-ply No. 7 or three-ply No. 10 cotton yarn makes the same size on cylinders as stated above.

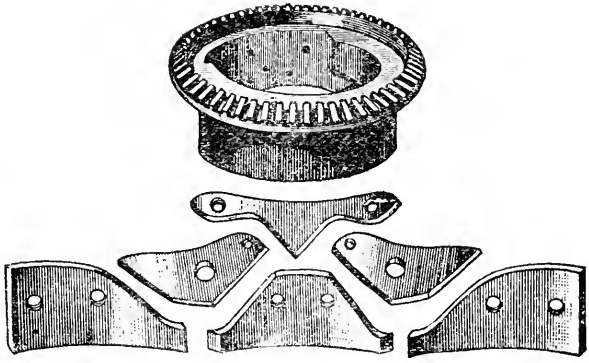


Fig. 117. Cams.

In making double heels and toes use a single thread of No. 10 or 12 cotton, or a single No. 18 or 20 worsted.

The length of the leg of ladies' or children's hose should be about three times the length of the foot.

To Change Heads. After removing the head from the machine put in the desired head, with the yarn carrier at the back of the machine directly opposite the yarn guide post, and with the crank hanging straight down with the handle at the lowest point. This will bring the handle in the easiest position for knitting the heel and toe with the backward and forward motion.

Setting-Up the Work. Turn the machine until the yarn carrier is directly in front of the machine. Have all the needles lying down all around the machine. Expand the set-up (See Fig. 121) so that the hooks rest against the inside of the needle cylinder as illustrated in Fig. 122. They should be held a little below the upper edge of the cylinder. Place the yarn in the yarn guide correctly and draw through the carrier; drawing through about a yard (enough to set up the first round, or course of stitches). Take the yarn between the thumb and finger close to the yarn carrier and put it under one of the hooks of the set-up,

then bring it up and around one of the needles in the machine close to the yarn carrier. (See Fig. 122). Always bring the yarn around the needle from the right to the left, and then down under the next hook of the set-up, and so on around each. This is continued on each needle until the needles down in the cams are reached, then hook the weights into the ring in the wire underneath the set-up and turn the machine

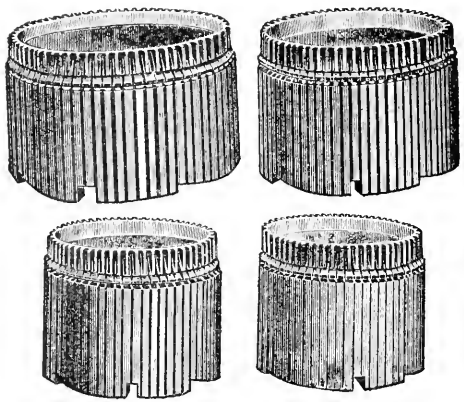


Fig. 118. Needle Cylinders.

slowly to the right until the remaining needles are brought up into full view. Continue to set up these needles as before, running over two or three of those that were first set up to fasten in the end of the yarn. Break off any yarn remaining in the fingers and the setting-up is completed. Note that bringing the yarn around the needle from the right to the left always forms a crossing of the yarn on the inside of the needle between it and the hook of the set-up, as shown in Fig. 123. If there are more needles in the machine than hooks in the set-up, catch under the same hook twice.

To Knit Rib Tops Without Removing the Needles. Before setting up the work lift up every fourth needle and tip it over at right angles with the cylinder, as shown in Fig. 124. The yarn carrier arm passes over these needles without operating them. Set up the work as previously instructed and knit the length of top desired. Then tip up and push down into the cylinder those needles that are away from the cams and yarn carrier, after which turn the machine forward and tip up and push down into the cylinder the rest of the needles. Then proceed with the knitting.

To Knit the Heel. On these machines there are marks on the upper edge of the needle cylinder dividing the cylinder exactly in halves, and the front is sub-divided into three equal parts, to serve as guides in knitting the heel and toe. Turn the yarn carrier to the front of the machine. Lift up, with the hook or fingers, all the needles in the back half of the cylinder as high as they will come, or up against the wire ring in the needle cylinder. Before turning the crank to revolve the machine, place the take-up spring under the yarn to bring it into action.

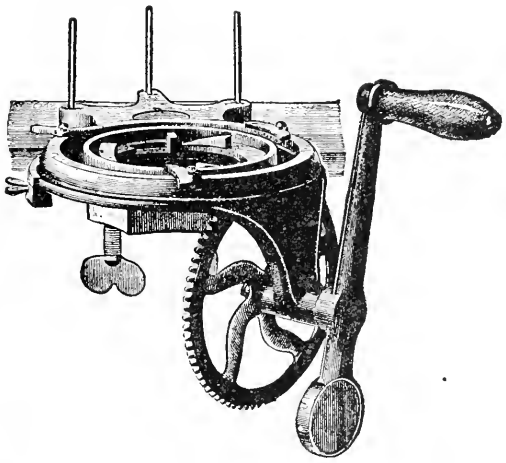


Fig. 119. Bed Plate.

Turn the machine until the needles in operation have all formed loops, then lift up one needle next to the yarn carrier and next to the needles already lifted up, as shown in Fig. 125. Turn the machine backward until the stitches are again formed on the opposite side, and again lift up one needle next to the yarn carrier and next to the needles already lifted up. Turn the machine forward again until stitches are formed on the side of the beginning, and then lift up a needle as before. Continue, in a like manner, to knit backward and forward, each time lifting a needle, until all the needles are lifted up next to the yarn carrier and next to the mark. Before moving the machine push down the first needle next to the mark on the *opposite* side and away from the yarn carrier.

During this operation of lifting up the needles, the weights at-

tached to the set-up are drawing down the work at the back of the machine, and not on the part then being knit. This latter part of the work must be held down with the left hand as shown in Fig. 125. Draw down on it so that the stitches will be kept down on the edge of the cylinder and properly knit in.

After the needles have all been lifted up to the marks and one has

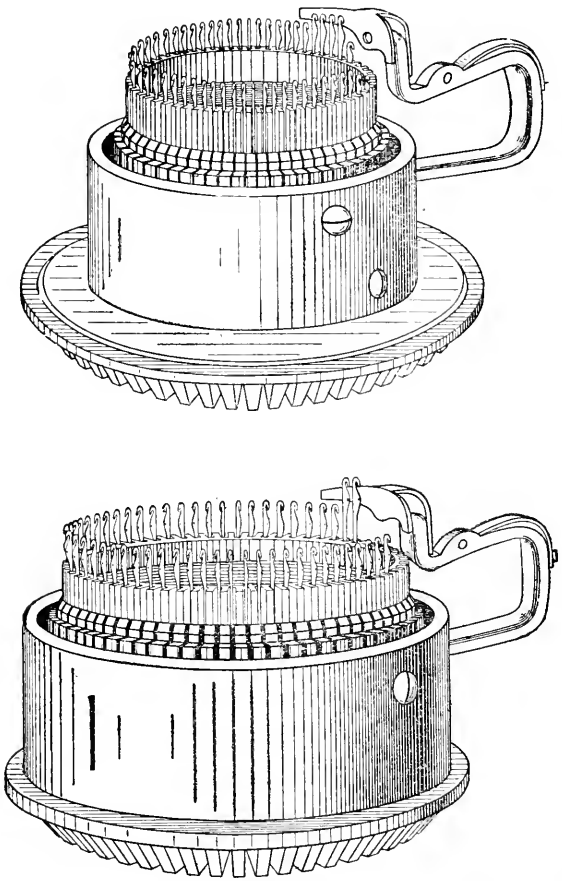


Fig. 120. Showing Arrangement for Holding Cylinders.

been pushed down on the opposite side from the carrier, push the heel hook up between the web and the cylinder and hook it into the web directly under the needles that are not lifted up, and about half an inch from the upper edge of the needle cylinder. Take the weights from

the set-up and hook into the ring in the lower end of the heel hook. Now push down a needle on the opposite side and away from the yarn carrier; knit across, and then push down another needle (always on the side away from the yarn-carrier). Knit across and continue to push down needles in a like manner until all are down to the marks where the start was made, except one on each side, these being the first ones raised up; turn the machines until the yarn carrier is directly in front, and push down all the lifted needles. Be sure that all the latches are down at the back of the machine, otherwise stitches will be dropped. Then proceed to knit the foot.

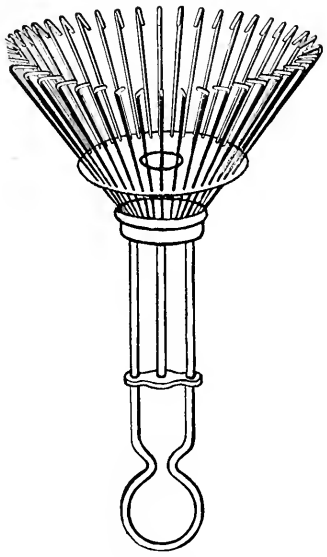


Fig. 121. Set-Up.

To Knit the Foot. With the left hand, catch hold of the leg of the stocking at the back of the machine and hold down on it, as the weight in the heel hooks are drawing only on the web in the front part of the machine. As all the needles are in use to knit the foot, as in knitting the leg, and as it is simply plain circular knitting, it is merely a matter of turning the crank in the right direction to make the cams actuate the needles, until the place is arrived at where the toe should be. Then proceed to knit the toe.

To Knit the Toe. The toe is knit, in every particular, like the heel. When completed, knit two rounds with the needles all down, break off the yarn and run the work out of the machine, holding the weights up so that they may not draw down too hard while running out.

To Knit a Mitten. Take out every fourth needle as in knitting rib top; set and knit the length required for wrist; put in the needles taken out, and lift the stitches over these needles to close the opening that is left if they are allowed to set their own stitches. Knit fourteen rounds of plain knitting, then lift up the needles as in knitting the heel of a stocking, leaving twenty-four down in operation. On these

needles knit the thumb. Knit back and forth forty-five times; close off the end of the thumb by lifting up six needles on each side; then proceed as in knitting a heel. Push down all the twenty-four needles and run the thumb out, leaving the yarn carrier on the left. Now take the selvedge stitches on each side of the thumb thus knit, beginning close at the bottom, and put them over the empty needles, twelve from each selvedge; put the yarn in the yarn carrier, push all the nee-

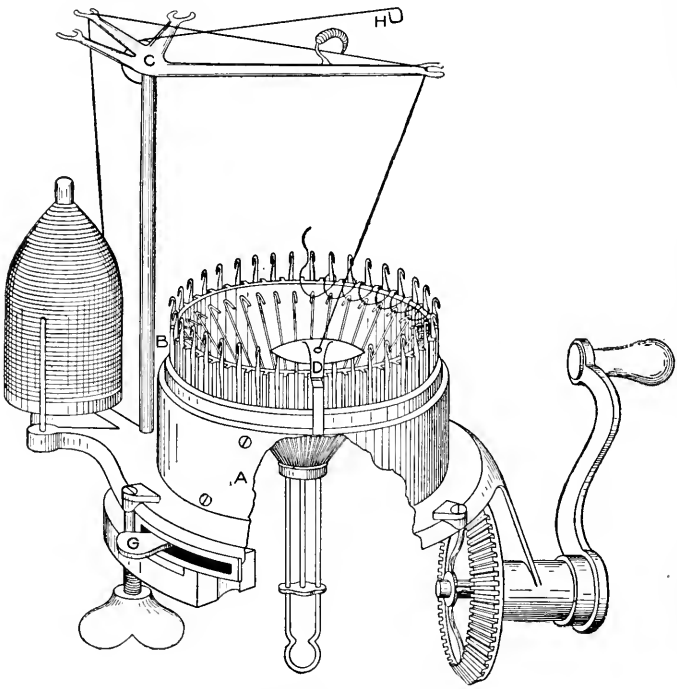


Fig. 122. Setting Up Work.

dles down, and knit round and round for the hand forty or fifty rounds. Close off as in the toe of the stocking. While knitting the thumb hold down the strip with the left hand or heel hook (B in Fig. 114).

To Close a Selvedge. Take up the short stitch with a darning needle on each edge on the wrong side of the fabric, and sew over as in over-seaming. Every other stitch on the selvedge is a short stitch and is referred to as the selvedge stitch.

Mending Broken Stitches. Take one of the needles of the ma-

LINKING ROOM WHERE CUFFS, ANKLES, ETC., ARE LINKED TO BODIES OF UNDERWEAR GARMENTS

Lawrence Mfg. Company

chine and hook it in the dropped stitch, either when the work is in the machine or after taking it out, and push it far enough through to bring the stitch below the latch. Continue to draw the needle back until a new stitch is formed, and continue in the same way until all the dropped stitches are knit in. If the mending is done out of the machine, tie the dropped stitch with a short piece of yarn and draw the ends inside of the web.

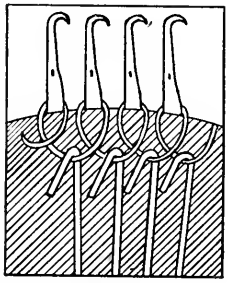


Fig. 123.
Crossing of Yarn.

To Take Out Needles. Lift them as high as they will raise up and then turn the tops outward and downward until they come out from under the wire ring in the needle cylinder. To put them in, press the end of the hub of the needle down behind the wire ring until it is fully down behind it, turn the needle up to the cylinder and push it down as far as it will go. Several needles can be taken out at one time as easily as one.

When the needles are raised up out of the cam cylinder against the wire ring in the cylinder, the hub of the needle projects above the cams and are not operated by them.

If the latch of a needle becomes bent, by accident or otherwise, straighten it with the fingers. See that all the latches work freely for if any do not they must be loosened or the needles will have to be replaced by new ones.

Do not attempt to reverse the machine while it is knitting, unless enough needles have been lifted up to allow the cams to pass under. The machine knits as well one way as the other, but it is awkward to turn it backwards.

Fig. 127 shows the manner of closing the toe with the "knitting stitch" which leaves no seam, and if done with the same yarn, cannot be distinguished from the other knitting.

The take-up spring should be adjusted to take up all the yarn drawn through the yarn carrier after leaving the operating needles. Too much tension will draw the stitches too tight at the selvedge, and too little tension will cause stitches to be dropped at the selvedge.

In knitting tight work put on plenty of weight or hold down hard with the left hand. Be sure that the yarn comes from the bobbin freely and without hindrance of any kind whatever. Much trouble

and poor work arise from poorly wound bobbins, and the yarn not coming off freely.

Table of Sizes of Yarn Used in Branson Machines

Needles to Inch	Wool Cuts Ply Cut	Cotton No. Ply No.	Worsted No. Ply No.	No. of Needles in 3¼" Machines
4	2–12	2– 4	2– 6	48
4½	2–14	2– 5	2– 7	52 & 56
5	2–14	2– 5	2– 7	60
5½	2–18	2– 6	2– 9	64
6	2–20	2– 7	2–10	68 & 72
6½	2–20	2– 7	2–10	76
7	2–22	2– 8	2–11	80 & 84
7½	2–25	2– 9	2–13	88
8	2–25	2– 9	2–13	92 & 96
8½	2–28	2–10	2–15	100
9	2–32	2–11	2–17	104 & 108
9½	2–38	2–14	2–19	112
10	2–38	2–14	2–19	116 & 112
10½	2–45	2–16	2–24	124
11	2–50	2–18	2–27	128 & 132
11½	2–56	2–20	2–30	136
12	2–56	2–20	2–30	140 & 144
12½	2–62	2–22	2–33	148
13	2–80	2–28	2–42	152 & 156
13½	2–96	2–34	2–50	160

AUTOMATIC MACHINES

The following preliminary description of the operation of knitting a sock on an automatic machine, gives a general idea of making a stocking, reference being had to the diagrammatic view, Fig. 130, in which the circular series of small dots represent the needles of the machine.

The needles may be said to be divided into sets, one set, namely, those inclosed with the bracket *a*, extending, say, one-half way around the machine; two sets *b b*, each extending about one-sixth or more of the distance around the machine on opposite sides of the same, and adjoining the ends of the set *a*; and finally a set *d*, extending between the sets *b*.

Supposing that the knitting of the sock or stocking is begun at the top of the leg, a thread is fed to all the needles and the machine is rotated so as to produce, by round-and-round knitting, continuous

circular courses of stitches until the desired length of tubular fabric for the leg has been formed, and it is necessary to form the heel.

In knitting a sock, the stitches of a short length of ribbed tubular fabric may be applied to the needles of the machine before commencing to knit the leg of the sock, so that when the sock is completed the leg

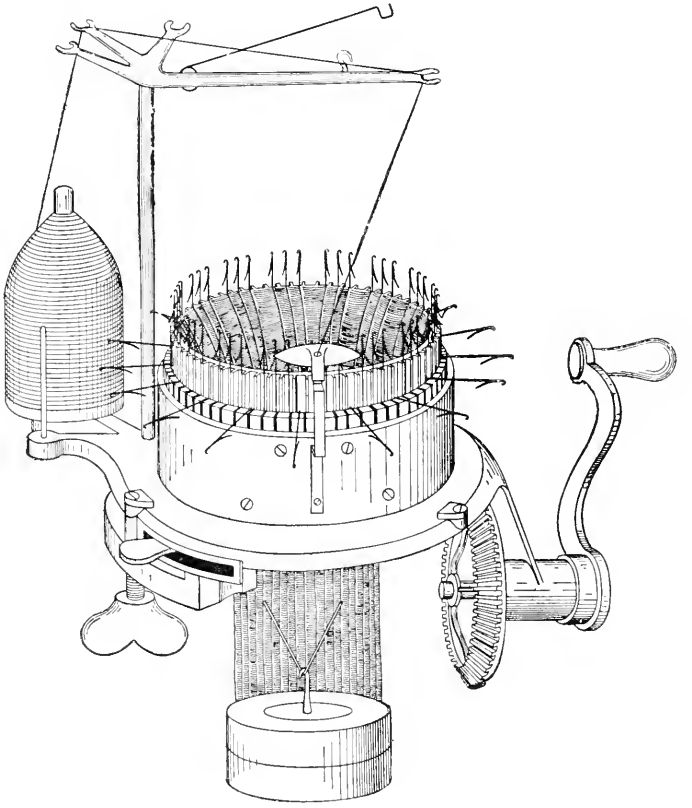


Fig. 124. Needles Tipped Down.

will have a ribbed top. In knitting long stockings where the ribbed top is not required, the needles may have greater draft while knitting the upper or calf part of the leg than while knitting the lower or ankle part, so as to shape the leg by drawing longer stitches and making a tube of greater diameter. After the proper length of tubular fabric has been produced the needles of the set *a* are, while still retaining their stitches, raised out of action. That is to say, they are raised so

that their butts will be above and free from the influence of the knitting cams, these cams being the ones which effect the vertical reciprocation of the needles at the proper time to cause them to catch the thread and draw the stitches. This leaves only the needles *b* and *d* in action. The motion of the machine is then changed from rotary to recipro-

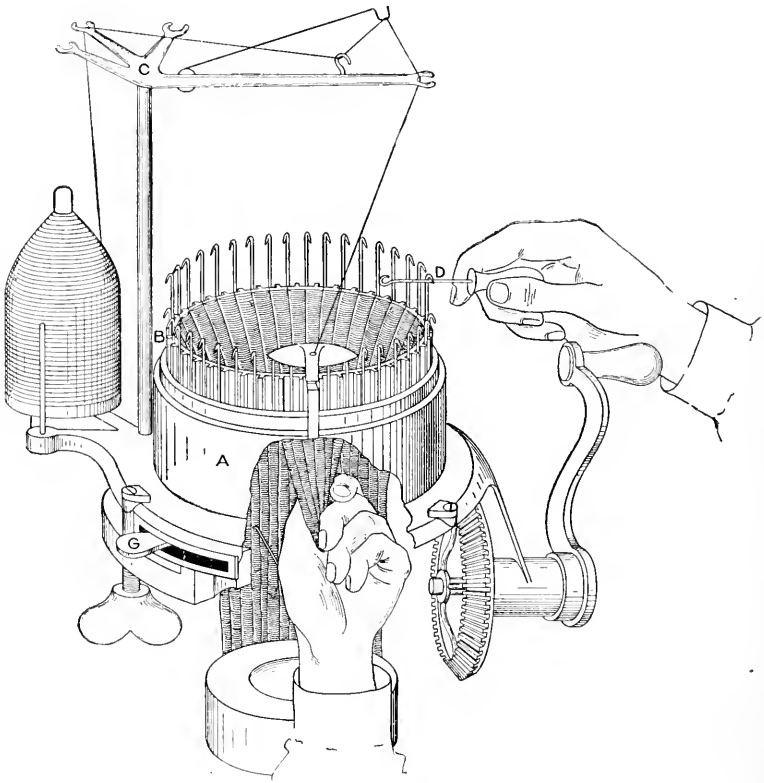


Fig. 125. Lifting Needles.

cating, and at the same time the extra or thickening thread is introduced, the double thread being carried back and forth around that part of the needle cylinder having the needles *b* and *d*, to form stitches upon these needles by to-and-fro knitting. The needles *b* are those upon which the fashioning of the toe and heel is effected and are termed "*fashioning-needles.*"

At the end of each reciprocating motion a needle, of one of the sets *b* at the end of the set adjacent to the needles *a*, is thrown out of

action—that is to say, it is so raised that its butt is free from the influence of the knitting-cams—but retains its stitch. The end needle, first of one fashioning set *b* and then of the opposite fashioning set *b*, is thus thrown out of action so that with each reciprocating movement the flat web produced is narrowed to the extent of one needle, first at one edge and then at the opposite edge. This narrowing operation is continued until all the needles of the fashioning sets *b b* have been thrown out of action.

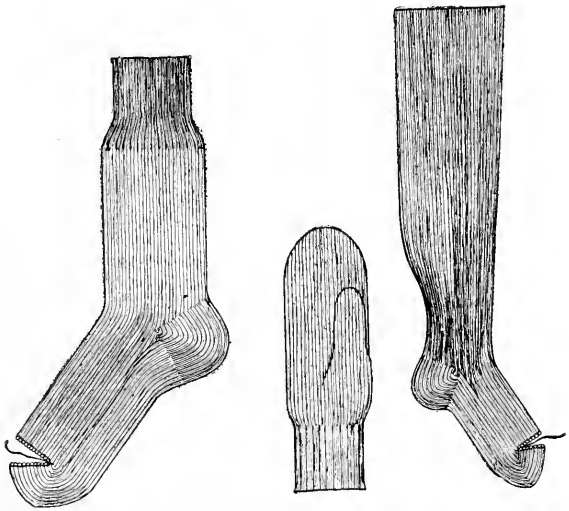


Fig. 126. Product of Branson Hand Machine.

Sometimes it is advisable to produce a series, of, say, two or more courses of stitches extending completely around the cylinder, to give greater depth or fullness to the center of the heel and prevent the stocking from binding at the instep. In this case all the needles *a* and *b* are temporarily lowered, so that their butts are again brought under the influence of the knitting-cams, and the motion of the machine is changed from reciprocating to rotary until the desired number of circular courses have been produced; the stitches carried by the needles *a* and *b* joining those of the first of the circular courses. It is also advisable to remove the thickening-thread during the formation of that part of each circular course which extends over the instep portion of the stocking.

As soon as the circular courses have been completed all the nee-

dles *a* and *b* are again raised out of action and the reciprocating motion of the machine is resumed. As soon as this has been done, needle after needle, first a needle of one fashioning set *b* and then a needle of the other set *b*, is brought into action by lowering the same so as to bring its butt under the control of the knitting-cams, the needles being brought into action in the reverse order from that in which they were thrown out of action. This operation results in the production of a gradually widened flat web, and in the uniting of this widened web to the last of the circular instep courses, owing to the fact that each of the fashioning needles *b*, retaining its stitches as it is thrown out of action after the formation of the circular courses, casts this stitch and catches

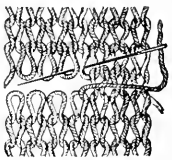


Fig. 127.
Method of Closing Toe.

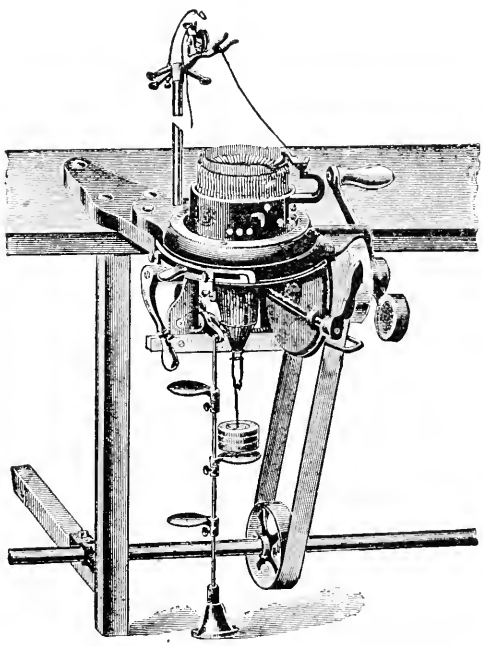


Fig. 128. Hand Machine with Power Attached.

a new loop formed upon the needles in effecting the production of the widened web. When all of the fashioning needles have been thus brought into action the thickening-thread is removed, the needles *a*

are lowered to bring their butts under the control of the knitting cams, and the motion of the machine is again changed from reciprocating to rotary.

This effect of the fashioning operation just described has been to

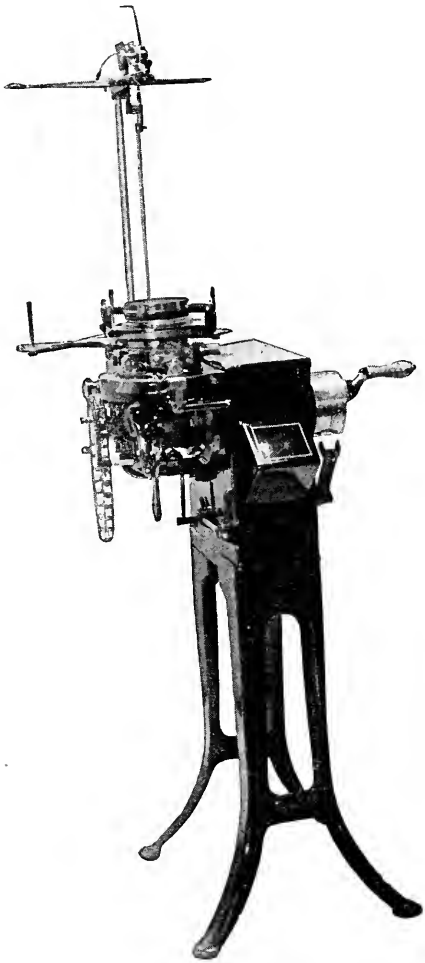


Fig. 129. Branson Full Automatic Machine.

produce a seamless pocket upon one side of the knitted tube, which constitutes the heel of the finished stocking, as shown in Fig. 131. *f* represents the narrowed web; *g*, the central circular courses; and *h*, the

widened web. After the heel has been completed the tubular web is resumed and continued until the same is of the length desired for the foot of the stocking, whereupon the operations resorted to in order to form the heel are repeated for the toe of the stocking.

The circular courses may be omitted from the instep and center of the heel, the narrowed web *f*, in this case, being united directly to the widened web *h*, or in other cases a series of courses extending around the entire heel, but not over the instep, may be formed after the narrowing operation and before the widening operation. In this case only the needles *b* are thrown into action after narrowing and they are again thrown out of action after the desired courses for the center of the heel have been produced.

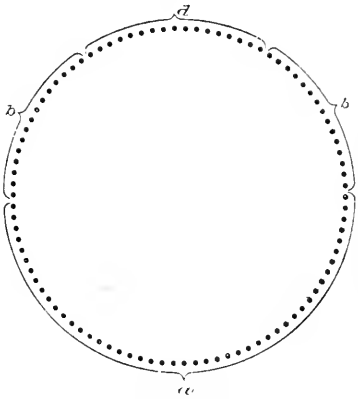


Fig. 130.
Diagrammatic View of Needles.

After the completion of the toe a few tubular courses are knitted and if the socks or stockings are being produced singly, the stitches may then cast off the needles of the machine to free the web therefrom, preparatory to starting a new stocking or applying a new ribbed top. If the machine is intended to operate continuously, and produce stocking after stocking in succession, the production of tubular web may, after the formation of each toe, be continued to form the leg of the next stocking, and so on, the web being afterward severed near each toe, so that each stocking blank will represent the appearance shown in Fig. 131; the toe being completed by uniting the edges *i i* in the usual manner.

FULL AUTOMATIC KNITTERS. ACME TYPE

A circular knitting machine of the Acme type, Fig. 132, comprises a stationary needle cylinder, an encircling rotating cam cylinder, and latch needles with butts or lateral projections in their shanks. The needle cylinder has a series of longitudinal, parallel grooves on its outer surface, and the cam cylinder is provided with suitable cams or inclines on its inner surface. The needles lie in the grooves of the needle cylinder, with their butts projecting outward. As the cam

cylinder revolves, the butts come in contact with and slide up and down the inclines or cams, and so cause the requisite up-and-down movement of the needles in the operation of knitting.

Operation. The needle is lowered to knit, by what is called the stitch cam, which has a diagonally inclined edge, and thus moves the needle down as the cam cylinder revolves. The cam cylinder also carries a yarn guide through which the thread is laid in the hook of the needle just before the needle is moved down by the stitch cam. As the needle moves downward, the latch is pulled up by the loop on the shank of the needle so as to close the hook of the needle, thus safely drawing down a new loop through the old one. When the needle rises again, the yarn in its hook pulls open the latch and turns it down upon the shank of the needle until the yarn has passed entirely below the latch, forming a loop around the shank through which, in turn, another loop is pulled down. Thus each needle pulls a series of loops, one through the other, forming a knitted fabric.

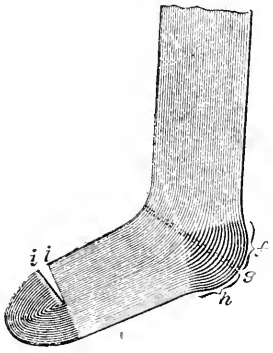


Fig. 131. Stocking as it Comes from Machine.

When the needle descends with a new loop the old loop is cast off over the closed hooked end of the needle, and forms a part of the tubular fabric which hangs down within the needle cylinder.

In knitting the tubular portions of a stocking, all the needles are in operation, and knit one course at each revolution of the cam cylinder. In knitting the heel or toe of a stocking, only a portion of the needles are in operation, and the cam cylinder is reciprocated, or moved first in one direction and then in the opposite direction. The heel and toe are in the form of a pouch or pocket, and they are knit by what is known as the narrowing and widening operation.

In this operation about one-half the number of needles are first raised to a higher level, or into an idle position, so that their butts will not be operated upon by the stitch cams. The other needles remain in an active position where their butts may be operated upon by the stitch cams. In the operation of narrowing, which then takes place, one of the active needles is shifted to a higher level, or to the idle series, at each reciprocation of the cam cylinder, by raising or elevating the

butt of the needle. When the narrowing is completed, the widening takes place by exactly the reverse operation; one of the idle needles is shifted to a lower level, or to the active series, at each reciprocation of the cam cylinder, by lowering or depressing the butt of the needle.

Sinkers. To operate this type of circular machines there are required devices known as jacks, sinkers, or web holders. These are thin blades of metal, one of which is placed between each two adjacent needle shanks. Each sinker has a longitudinal movement, inwardly and outwardly toward and from the center of the needle cylinder, in suitable guides near the upper edge of said cylinder; its movement being regulated by a cam which accompanies the movement of the cam cylinder. Each jack has a finger which, when the jack is advanced, overlies the last course of yarn which forms the upper edge of the fabric, and so holds the loops on the needle shanks from rising, as they otherwise would do, when the needles adjacent to the jack are pushed upward through the loops last formed by them, in order to receive the yarn for the loop of the next course. The bottom of the notch or recess formed by the overhanging finger bears against the edge of the fabric, and thus the jacks on either side of a given needle, when advanced, tend to pull the yarn tight around the shank of the needle. After the needle has risen and received the yarn, the jacks adjacent to it are moved outward a short distance so that the fingers will be out of the way of the yarn drawn down by the descending needle, which thus forms the new edge of the fabric. The jacks are again advanced, previous to the next rise of the needles, to hold down the edge of the fabric just formed.

Thus the primary elements of the circular knitting machine, are the *latch needles, grooved needle cylinder, cam cylinder, stitch cams,* and *sinkers,* and they alone would be necessary for knitting a plain tubular fabric by what is called circular knitting. in which all the needles are kept in continuous operation.

In knitting a stocking, however, which is the principal purpose for which these machines are employed, we find a further problem. In knitting the heel or toe, about one-half of the needles are lifted so that their butts are above the level of the stitch cams, and these needles thus remain idle; no longer being pulled down to knit. These are often spoken of as the long heeled needles, because their butts are longer than those of the other needles, so that they may be engaged by

a cam and lifted out of the row of operative needles On the remaining needles a progressively narrowing strip of fabric is knitted, and then a progressively widening strip is knitted, until a pouch is com-

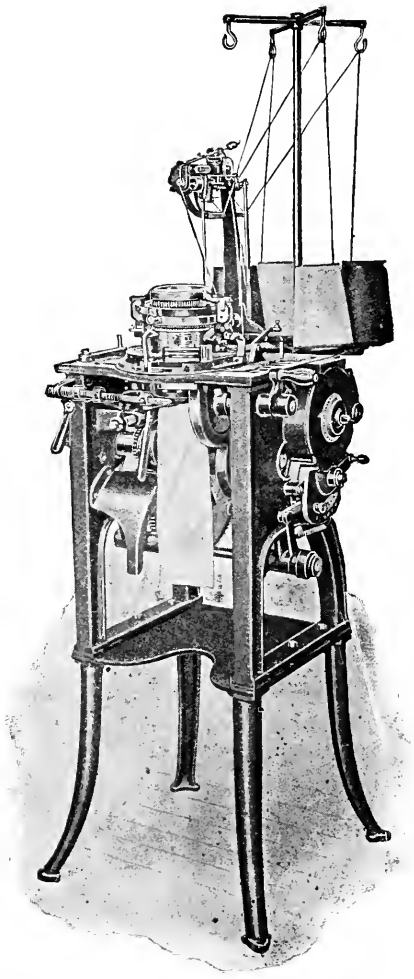


Fig. 132. Acme Full Automatic Machine.

pleted which forms the heel. After the heel is completed the long needles are thrown back into action and circular knitting is resumed for the foot of the stocking.

Narrowing. The cam cylinder, when knitting the heel or toe of the stocking, is not rotated, but reciprocates first in one direction and

then in the other, and with each reciprocation of the cam cylinder the needle at the forward end of the row of active needles (*i. e.*, the one which would be first encountered by the stitch cam and be lowered so as to knit) is lifted up into the plane of inactive needles. Thus the fabric knit by the needles grows narrower by one loop with each reciprocation of the cam cylinder, and this is accordingly called the "narrowing" operation.

Widening. After the narrowest portion of the fabric has been arrived at, only a small number of needles being left still in operation, the "widening" operation begins. This operation consists in first throwing one needle out of operation and then throwing two needles into operation on each reciprocation of the cam cylinder. This is continued until all the needles removed in the narrowing process have been brought back and the pouch has been knitted. Then the long heeled needles are all brought down simultaneously into active position, and circular knitting is resumed. This is called the *two-and-one method.*

The two-and-one method has been adopted in the widening process for the following reasons: In the one-and-one method the last needle to knit in the widening operation, as the cam cylinder moves in one direction, is the first needle to knit on the next course on the return reciprocation of the cam cylinder in the opposite direction. This needle, therefore, draws two loops, with the result that a series of small holes is left along the line or seam where the narrowed and widened portions are joined in the heel or toe pocket. This disadvantage is overcome by the two-and-one method, by which the last needle to knit in a given course is thrown out of operation on the return reciprocation of the cam cylinder, and therefore it is not the first to knit on the next course. To express the effect in another form, in knitting each course one needle knits beyond the needle which is the first to knit in the next returning course.

In the earlier machines of the Acme type, all the rotary knitting of the body of the stocking was automatic, while the reciprocating knitting of the heel and toe was done by hand. When the rotary knitting was partially or wholly completed, or when the heel or toe were to be knit, the machine was stopped, and about one-half the needles shifted to an idle position. In the narrowing and widening operation which followed, the individual needles were raised by a pick

or hook in the hand of the operator, and depressed by the finger of the operator. As the result of this use of a pick to shift the needles, the term "*picker*" has come to designate the means by which the needles are shifted in an automatic machine, and the machine itself is called the "picker machine."

The pickers, which raise the needles are known as elevating or lifting pickers, or *lifters,* and the pickers which depress the needles are known as the depressing pickers, or *droppers.* Two lifting pickers are used in automatic reciprocating knitting, one operating when the cam cylinder moves in the opposite direction and the same, of course, is true of the depressing pickers because there must be two stitch-cam arrangements on the cylinder in reciprocating knitting, one operating when the cylinder is moved in the opposite direction.

In order to automatically shift the needles in narrowing and widening, pickers are mounted on the cam cylinder, each of which in turn, as that cylinder is reciprocated, comes in contact with the butt of the needle or needles to be shifted, and is so organized that it thereupon automatically shifts the needles while the needle moves the picker.

There are four of these pickers upon the cam cylinder, namely, a pair of "lifters" for raising the needles from operative to inoperative position, one operating on the reciprocation of the cam cylinder in one direction, and another on the reverse reciprocation, and lastly a pair of "droppers" for similarly lowering the needles from inoperative to operative position.

These (lifting) pickers are provided, at their ends, with recesses or notches for receiving the needle butts, the notches being so formed that there is a lip or finger underlying the needle butt when it is in engagement with the notched end of the picker. The pickers are mounted upon the cam cylinder so that they move in an inclined or diagonal direction, and when a needle butt engages the notch of the picker, that picker is moved backward and upward, with relation to the cam cylinder, and the lip of the picker engages the underside of the needle butt, carrying the needle upward out of the active series, the needle butt being transformed from the notch of the picker to an inclined guide or cam which completes its movement, from the active or working series, to the idle series.

The devices for transferring the needles, individually, from the idle to the working series, during the widening operation are similar to the

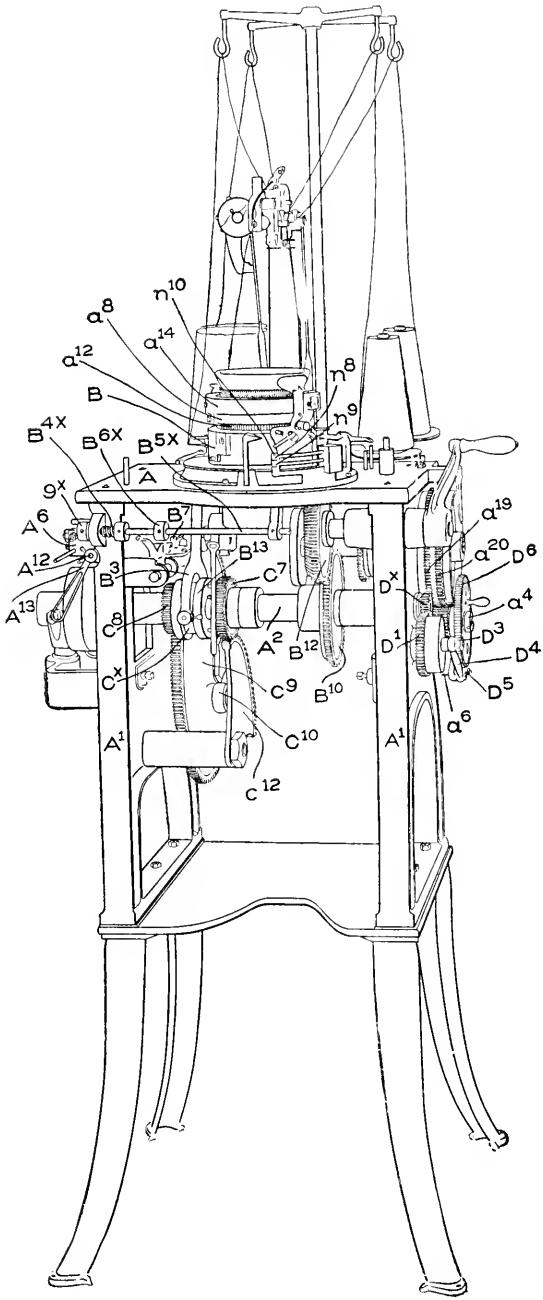


Fig. 133. Acme Full Automatic Machine.

pickers for transferring the needles from the working to the idle series during the narrowing operation, the only difference being that the depressing pickers are provided with lips which overlie the needle butt, which is in engagement with the notched end of the picker, and the picker is arranged to move downward when engaged by a needle butt and thus carry the needle downward from the idle towards the working series.

In other words the pickers operate as follows, taking, for example, the lifter: As the cam cylinder rotates, the notched end of the lifter comes against the butt of the first needle in the row of active needles. The needle, being held in a vertical groove in the stationary needle cylinder, cannot move sidewise, and so its butt stops the lifter from further motion with the cam cylinder, or in other words, forces it backward relatively to the advancing cam cylinder. The lifter is so mounted that it can retreat only in a diagonally upward path, and since it has a finger which underlies the needle butt, it carries the needle butt with it, and thus lifts the needle to inoperative position, the needle rising in its groove. The butts or heels of these needles which are in operation are just above the ledge of the cam cylinder, so as to be in the path of the stitch cam and be thereby pulled down so as to knit. The inactive needles are in a higher plane, with their butts above the guide plates, so as to be completely out of the path of the stitch cams.

The Acme machine employs a rotary winder device for winding the free end of the thickening or extra thread around the main thread.

Winder. The construction of this winder is such that, when the winding of the free end of the thickening thread about the main thread has been completed, the free end of the thickening thread can be pulled out from the winder by the main thread, without being unclamped from the winder. It consists of a stationary stud or boss having in it two thread passages, one for the main thread, and the other for the thickening thread. The main thread runs continuously through its passage, thence through a thread eye and take-up to the needles. Mounted upon the stationary boss, so as to be capable of rotation thereon, is the shell or sleeve, which forms the winder. Upon the end of the winder or sleeve are formed a number of projections of wire or bristles in the form of a ring-like brush.

When it is desired to withdraw the thickening thread from the main thread, the hook upon the three-armed lever pulls the thickening

thread to one side so as to engage one of the spaces or slots between the bristles at the end of the winder, and the further movement of the lever causes its lower arm to strike an arm connected with the jaw, and so to sever the thickening thread, the end of which remains in the slot in the end of the winder until the next operation thereof.

The Acme machine illustrated in Fig. 133 is a full automatic, built in what is sometimes termed a box pattern style. The head or knitting cylinder is located in the bed plate so that the work is directly in front of the machine. The skeleton cylinder is one of the distinctive features of this machine, which is also true of the pattern wheel system for regulating the length of the tubular knitting, the length of the stitch and also to operate the stop motion at the completion of the stocking.

When the machine changes to the reciprocating motion to knit the heel or toe, the pattern wheel is automatically thrown out of action and a ratchet wheel is provided to take its place while knitting the heel or toe. This ratchet feeds one tooth for each needle required to narrow, and one tooth for each needle required to widen, and requires one full revolution to complete the heel or toe. When the machine changes again to rotary motion, the pattern wheel is automatically thrown into action and completes the tubular portion of the stocking.

A transfer cup or quill ring is used for transferring, instead of changing cylinders.

These machines are built in $\frac{1}{4}$ inch sizes, from 2 to $4\frac{1}{4}$ inches with any number of needles up to 17 to the inch.

The Needle Cylinder is represented as a vertical section in Fig 134. This illustration also shows some of the parts connected with it. a^2 and a^7 are the needle cylinder proper, supported in the cylinder guide O which surrounds and retains the lower end of the needle cylinder. At this end of the needle cylinder, between it and the cylinder guide, is a cam ring n^1 with the projection n^0 which, when the cam ring is rotated and also by reason of the inclined portions of the cylinder bottom, allows the cylinder to descend by gravity, thus shortening the stitch and reducing at the desired place the size of the stocking. A guide block r^2 (See also Fig. 136), which is fastened in the cylinder guide and extends into the vertical slot, r^0, in the cylinder, serves to guide the needle cylinder in its vertical movement and to prevent it from turning.

The upper end of the needle cylinder a^2 is made broader or thick-

VIEW IN KNITTING ROOM OF SHAW STOCKING CO., SHOWING SHAW AUTOMATIC POWER JACQUARD STOCKING LOOMS

er by the addition of the ring a^7 to its interior. The ring is fastened to the cylinder with a screw 4 and has a projecting ledge a^9 which supports the jack support-ring a^8, which is in turn secured to the cylinder by means of the screw 5. The jack supporting ring is slotted on the top edge to form a support for the outer ends of the jacks a^{10}, and similar grooves are provided in the upper end of the part a^7 of the needle cylinder, for the inner ends of the jack. Each jack is made with a projection a^5 to enter the annular groove in the ring a^{14}, which is movably mounted to rotate on the jack supporting ring a^8. It is the function of the jack ring a^{14}, with its cam shaped groove, to operate the jacks and withdraw their fingers a^6 out of the paths of the needles when a stitch is being formed.

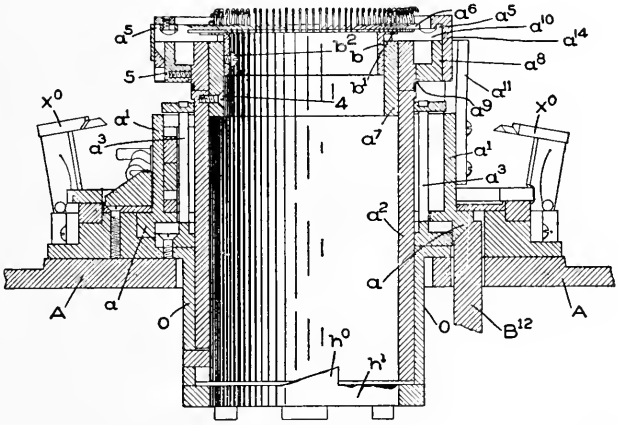


Fig. 134. Needle Cylinder.

The ring a^{14} rests directly upon, and is supported by, the ring a^8, and is operated from the cam cylinder a^1 by means of an arm a^{11}, which is fixed to the latter and engages with the stops projecting outward from the jack ring a^{14}. Adjusting screws are inserted in the stops and are acted upon by the arm a^{11}—one when the cam cylinder is moved in one direction, and the other when the cam cylinder is moved in the opposite direction. This enables the cam for moving the sinkers, and the knitting cams to be put in their proper relative positions during the knitting operation, as is necessary in machines using sinkers, there being more or less lost motion between the sinker cam ring and the cam cylinders during the changes in reciprocating knitting.

The Jacks a^{10} which take the stitches as they are formed and push them back from the needles thus taking-up the work as fast as it is knit, are prevented from being raised (by the work) by the ring b which is provided with the flange b^1. Between the flanges and the

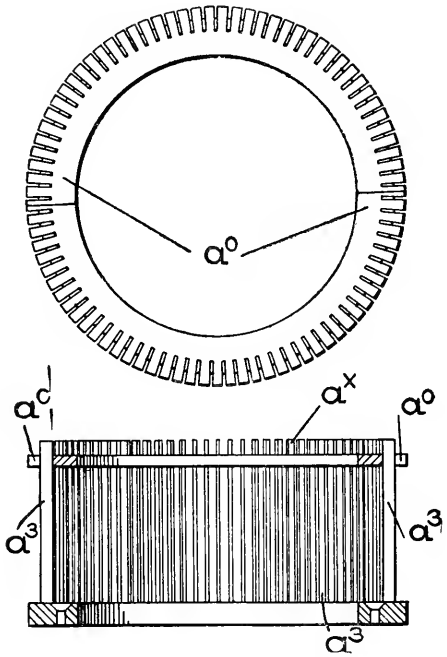


Fig. 135. Skeleton Cylinder.

top of the needle cylinder, are contained the jacks, free to be actuated horizontally in the groove in the jack cam ring a^{14}. The ring b is secured to the needle cylinder by means of a set screw b^2.

In circular knitting the cam for moving the sinkers is so located with relation to the drawing down surfaces as to pull the sinkers out as the needles commence their descent, the groove of the sinker operating cam ring pushing the sinkers inward preparatory to the rising of the needles to take the stitch of yarn.

The sinker cam ring is provided with adjusting screws to time the action of the sinkers. The sinkers also perform the function of web-holders. The sinker ring is fastened to the needle cylinder with screws, and is not to be removed therefrom except when necessary for unusual repairs.

The droppers and lifters X^0 are operated by a cam and swing outward, carrying the needle up or down as required, and locking themselves in position for the next needle. The stitch gauge is on the front of the machine and the stitch may readily be changed in any part of the stocking without interfering with any of the other working parts.

The Acme is of that type of automatics in which the quill ring or transfer cup is employed for making socks or half hose with rib tops, or when rib legs are to be footed, as in the case of boy's stockings, consequently the needles are run up on a level and then lowered into the cylinder by raising the needle cylinder.

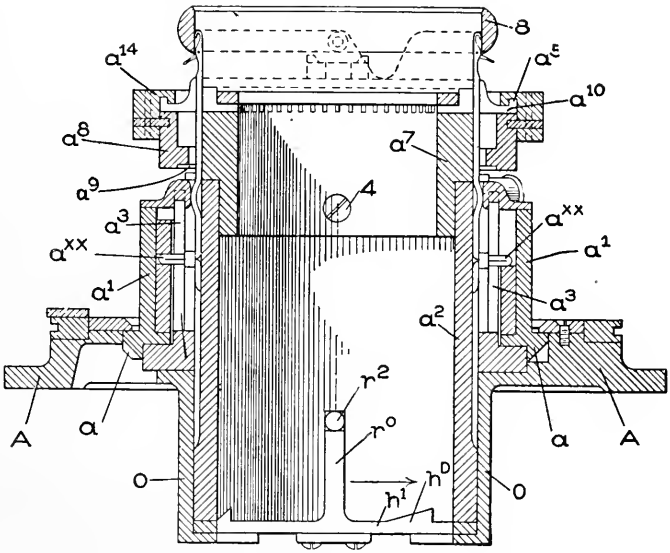


Fig. 136. View of Cylinder Showing Latch-Guard Ring.

A Skeleton Cylinder (Fig. 135 and a^3 in Figs. 134 and 136) is placed between the needle cylinder and the cam cylinder, and fastened to the bed plate, or needle cylinder socket, of the machine. The bars or walls a^x of the skeleton cylinder line with the lands or walls of the needle cylinder proper. The slots in the needle cylinder are cut deep enough to provide a good bearing for the needles, and the bars of the skeleton serve as guides to the butts a^{xx} of the needles, which extend outwardly between the bars and through to the cam cylinder in which are disposed the cams to actuate them As the skeleton cylinder is fastened to the bed plate by means of screws, it can be readily removed

and substituted by another having a greater or less number of bars, according as it is desired to adapt the machine to knit coarse or fine fabrics. When the skeleton is changed it will, of course, be necessary to change the needle cylinder so that the spaces and slots will correspond and be of the same gauge.

The Cam Cylinder is so constructed that the needles are drawn down from a common level to take the stitch and then returned to the same level. When the needles are on this level, the latches are above the stitches that are on the needles, and to prevent the latches from closing and casting off the stitch, a latch guard ring (8, Fig. 136) is provided, which also feeds or guides the thread to the needles.

The cam cylinder is rotated or reciprocated, as the character of the knitting requires, by means of a bevel toothed gear, B^{12}, engaging with the bevel teeth a cut in the lower edge of the cam cylinder a^1.

Method of Driving. In the illustrations shown at Figs. 133 and 137 the table or bed is represented by A and rests on the supports A^1, to which are also secured the several mechanisms contained in the machine for effecting the different knitting processes. The main shaft A^2, sometimes called the cam shaft, is provided with two loose pulleys for the driving belt, which is under the control of the shipper fork and its actuating mechanism. This mechanism consists of a block A^6 which slides on a stud and is acted upon by the spiral spring B^{1x} to keep the belt upon the outer pulley; the belt being shifted by means of a link A^9 connected to the block and to an arm of a rock shaft A^{12}, which is mounted in bearings at the side of the machine, and has a handle A^{13} which is used to start the machine. When the handle has been turned far enough to shift the belt on to the inner pulley, the arm will rest on or just above one arm of the pivoted elbow lever B^4. The link has an adjusting screw which may be adjusted so as to strike the arm sooner or later after the pivot, which connects the link and arm, passes the line of center of the rock shaft, to thus determine the ease of motion of the link.

The cam shaft has fast on it a gear B^{12} which engages the beveled teeth a in the lower end of the cam cylinder a'. On the main shaft A^2 is the hub part of a clutch B^{13} held fast to turn with the shaft by a feather, B^x, but loose to move endways, the hub being grooved on the outside to receive a two part ring C^x which is connected by means of studs to the forked clutch arm B^3 which is pivoted at B^1 and connect-

ed by the link B^6 with the pin 2 located at the inner end of the clutch lever D^{13} (Figs. 139 and 140). The clutch lever is pivoted at D^{14}.

The hub B^{13} (See Fig. 137) has at its sides, spring-actuated pins *a* and *b* projecting through the washers on the sides of the hub. A short distance from the hub is a loose gear C^7 mounted on a flanged bushing and collar arrangement secured to the shaft by a set screw and provided with a hole in the clutch face to receive the pin. At the opposite side of the hub and loose upon the shaft, is the pinion C^8 which is secured to the sleeve of the loose pulley A^3. When the machine is in motion this pinion engages and drives the large gear C^9. In the face of the pinion is a hole to receive the pin *b* in the clutch hub.

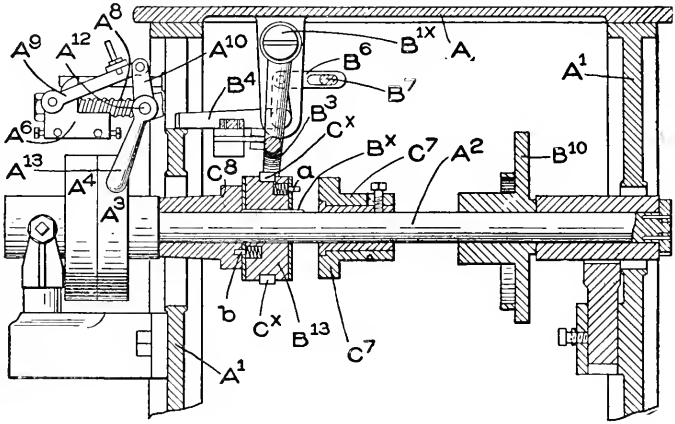


Fig. 137. Method of Driving.

The gear C^9 has a crank pin (See Figs. 138 and 139) provided with a link C^{10} which, at its opposite end, is attached to a stud on the segment gear C^{12} pivoted at C^{13}, the segment engaging the loose gear C^7 and oscillating it continuously. When the pin *b* of the clutch hub B^{13} engages the gear C^8 the main shaft will be rotated for circular knitting, and the segment will move the loose gear C^7 back and forth on the bushing, but when the hub is shifted, so that the pin *a* of the clutch engages the gear C^7, the latter becomes fastened to the main shaft, and the segment actuating it will oscillate the shaft for reciprocal knitting for heel and toe work.

The Pattern Wheel System. The main shaft A^2 has secured to it at one end (See Figs. 133 and 138) the pinion D^x by means of which motion is transmitted through the connecting pawl operating mechan-

ism. This mechanism consists of the gear D^1; the adjustably mounted crank pin D^3, which is attached to the link D^4; the pawl carrier D^5, which is pivoted on the stud a^4 and on which is mounted a spring actuated pawl to engage the teeth of the ratchet wheel D^6. This ratchet wheel is the prime mover of the pattern wheel system peculiar to this machine.

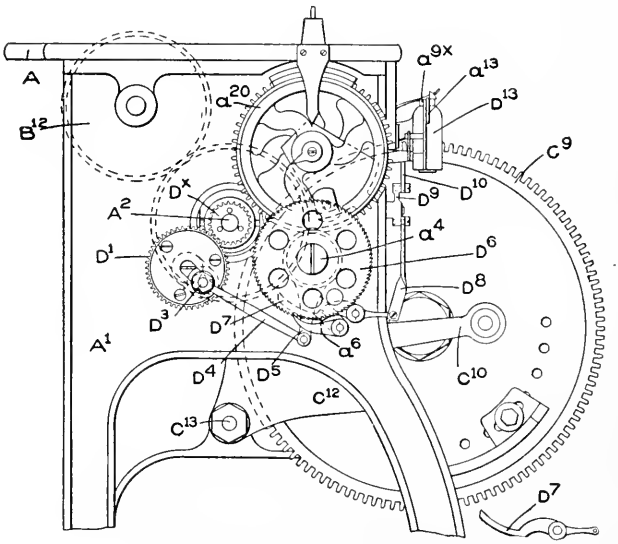


Fig. 138. Gears and Ratchets.

The crank pin D^3 may be adjusted to control the stroke of the pawl, so that it will move the ratchet wheel the distance of one or any desired number of teeth; the greater the movement of the ratchet wheel the shorter the stocking, and *vice versa*. The pawl has in its side, a pin a^6 which, when the knitting is to be changed from circular to heel and toe knitting, during which time the pattern wheels a^{19} and a^{20} in Figs. 142 and 138 are left at rest, is struck by one end of a lever D^7, connected with a link D^8, Fig. 138, with an elbow lever D^9 pivoted at D^{12} (See Fig. 139) to a lug 4, projecting from the clutch lever D^{13} (also shown in Fig. 138) which latter is moved when the change from circular to reciprocal knitting and *vice versa* is to be made by the pattern wheel.

The outer end of the clutch lever D^{13} (Figs 138 and 139) is forked to embrace the wheel C^9, each fork being provided with sliding pins

a^{9x} and a^{10x} (See Fig. 140), each pin having at or near one end a projecting cross pin, entering inclined slots in the sliding bar a^{13} which is moved in one or the other direction, according as it is desired to change from circular to reciprocal knitting or *vice versa*.

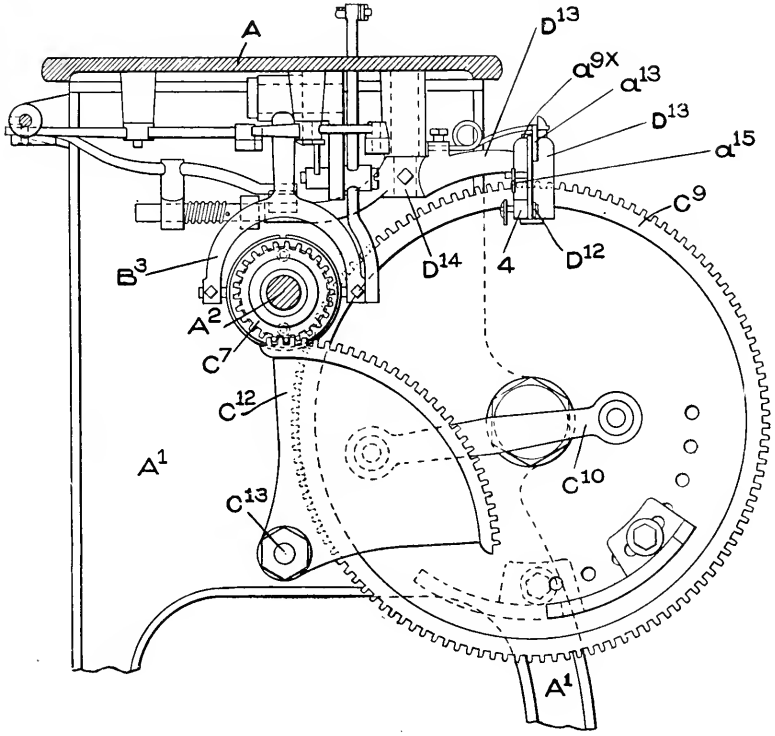


Fig. 139.

The bar a^{13} has connected to it a lever pivoted at D^{12} and having connected to it a link slotted at one end to embrace and slide on a screw stud carried by a change lever a^{17} (Fig. 141) with three arms, and being pivoted on a stand attached to the bed.

The change lever a^{17} is acted upon its right-hand end when the change from circular to reciprocal knitting is to be made, by a latch b^3 which forms a part of the pattern wheel system, and is carried by the radius bar b^1 (Fig. 141) mounted loosely on the hub b^{5x} of the disc b^5 fast on the shaft E (see also Fig. 142) having as its bearing the short sleeve c^3, the bar having an attached clamping dog b^4, bearing against the outer edge of the disc with sufficient friction to cause the

bar to rotate with it and strike the lever a^{17} at the proper time. A spring b^6 acts on the latch b^3 to hold it normally away from the bar.

The left hand end of the change lever is acted upon, when the change from reciprocal to circular knitting is to be made, by a latch pivoted on a radius bar c^1, the ring of the bar surrounding the hub c^2 of a disc, loose on the sleeve c^3 which is secured to the table or bed support A^1. The bar c^1 is adjustable about the hub by means of a set screw in a slot of the arm c^1. A spring acts on a latch to normally press it away from the bar c^1.

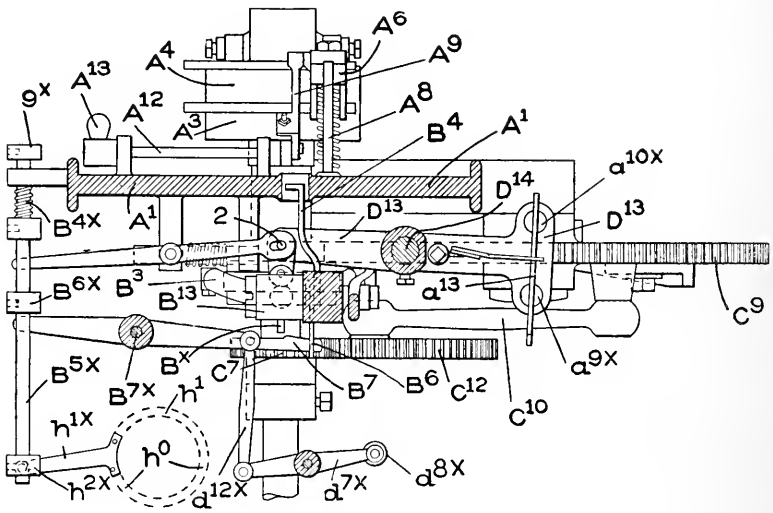


Fig. 140.

The switch D for raising up the needles not to be used for heel and toe work, and for letting them down when they are required for circular or round and round work, has, see Fig. 143, its stem projecting through the plate N attached to the outer side of the cam cylinder B. The stem outside the plate has feather-splined on it a gear n^1, which is kept on by the screw n^2. The gear meshes into the rach n^3, which is connected to the slide block n^4, fitted into the guideway n^5 of the plate N. When the rack is moved up it turns the gear on the stem of the switch and sets it in position to raise up and put out of action those needles which are not required for knitting the heel and toe, the rack being lowered to put the switch in position, after a heel or toe has been

finished, to lead down all the needles previously lifted, and then to be raised in circular knitting.

The rack has a cam face at one side, with which co-operates a locking device n^6, which serves to hold the rack in position as left by its actuating device. When the narrowing in the heel and toe work is about to begin, the projecting pin n^7 (See Fig. 143) is struck by the lower one of the pair of switch shifter levers n^8 and n^9 (See Fig. 144) pivoted at n^{10}. One shifter rests above the other, and each is acted upon by a spring n^{12} to keep the acting ends pressed toward the cam cylinder. The lower switch shifter has a place milled out as at 5, into which enters a projection n^{13}, carried by the shifter ring c^{14} which has imparted to it a slight movement in the direction of the arrow, shown at Fig. 144, just as the change from the straight or round and round work to the heel or toe knitting is to be effected which moves the projection into the milled place on the lever or shifter n^8 permitting the cam shaped end to move into the path of movement of the pin n^7, Fig. 143. At the same time the projection n^{13} acts against and moves the upper shifter in the opposite direction.

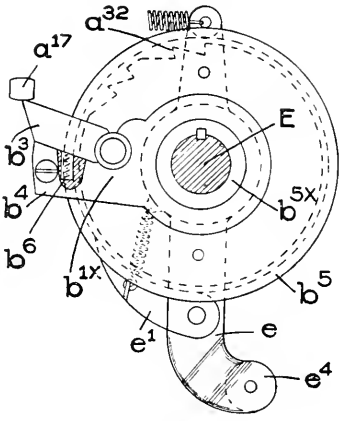


Fig. 141.

After the heel or toe has been completed the ring c^{14} is moved in the opposite direction, causing the projection n^{13} to act on and move outwardly the shifter n^8, and let the shifter n^9 come into action to strike the upper side of the pin n^7 and move the rack and switch D to guide all the needles again into position for straight work or circular knitting

Changing the Length of Stitch. When a stocking is to be started, the stitches in the larger part of the leg should be a little looser or longer than in the lower part of the leg and in the foot. This is accomplished by mechanism for raising and lowering the needle cylinder. Notches are provided in the lower end of the needle cylinder which rests on the ring h^1 and which is provided with projections h^0 (See Figs. 140 and 136). To move this ring so that the projections will

enter and move out of the notches and thereby raise and lower the cylinder, power is obtained from the cam d^6 on the inner end of the shaft E (See Fig. 142) by means of the connecting levers d^{7x}, d^{12x}, B^7, and the rod B^{5x} connected to the lever h^{1x} attached to the movable needle cylinder elevating ring h' (See Fig. 140).

At the commencement of a stocking, where the largest tubular portion is desired, the cam roller d^{8x} should stand on the lower part of the cam d^6 just beyond the high part 12, and in such condition that the lever B^7 acts against the collar B^{6x} and compresses the spring B^{4x}. As the knitting progresses the cam travels along by the roller and when the leg should be contracted, the cam d^9 acts on the roller. The lever is gradually moved back from the collar B^{6x} thus permitting the spring B^{4x} to move the rod B^{5x} and with it the lever h^{1x}, bringing the projection on the ring into the notch in the cylinder thereby letting it descend into the position for the shortest stitches to be made. The extent of this movement is regulated by the adjusting collar 9^x.

When the toe is about completed, the cam d^6 meets the roller d^{8x} and just at this time the lever e is moved, causing the pawl e^1 to engage the ratchet teeth a^{32} shown at Fig. 141, and impart to the plate d a quicker movement than would be effected by the gear wheels, thus giving to the levers d^{7x} and B^7 quick movements causing the outer end of the lever B^7 to act upon the collar B^{6x} and push the rod in the direction to turn the needle cylinder elevating ring, and thus lift the cylinder quickly to provide for stitches of the greatest length, and as the roller passes over the high part 12 (Fig. 142) longer stitches will be made for a slack course. The slack course forms a line around the stocking to indicate the loops to separate the stocking from the continuous string.

The Stop Mechanism. The elbow lever B^4, shown at Fig. 137, has connected to it a slotted link B^6, in which is placed one end of the tension lever B^7 shown at Fig. 140, and pivoted at B^{7x}. The tension lever is moved by the high part 12, at the completion of each stocking, to turn the arm B^4 and cause it to act on the arm A^{10} and turn it far enough to let the spring A^8 act to shift the belt onto the outer pulley, and thus stop the machine.

Just as the stocking is finished, if the machine is to be stopped, the first abrupt end of the cam meets the roller d^{8x} on the lever d^{7x} and

stops or rests on the cam d^6, just behind the high part 12, in position to start the machine.

The machine having been stopped and the stocking run off, it may be again started, and if the stocking is to be short and knitted to a ribbed top, then but one abrupt part d^{6x} and the high part 12 will be necessary, but in case it is desired to knit stockings connected together, the web of stockings to be separated after being taken from the machine, remove the link B^6 shown at Fig. 141, so that after one or more regular courses have been knitted, the needle cylinder may again be

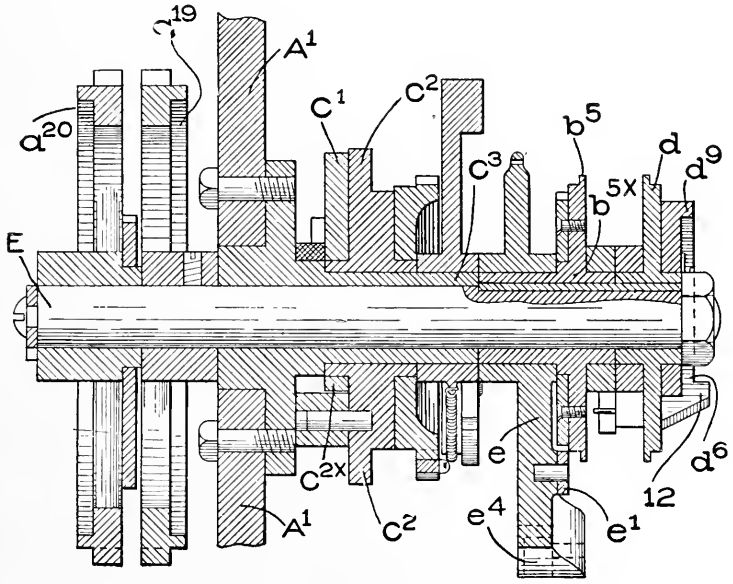


Fig. 142. Cam Shaft.

raised to make a second slack course by means of which to accurately separate or sever the leg of one stocking from the toe of a previously knitted stocking, and then return to the regular knitting.

The automatic twister or reinforcing attachment is provided for twisting the end of the reinforcing or thickening thread around the main or knitting thread to reinforce or thicken the heel or toe. Means are also provided to cut out the reinforcing thread when the heel or toe is finished, leaving the thread in position to be automatically twisted in again for the next heel or toe. Another attachment is provided for automatically changing the yarn in the heel and toe to a

yarn of a different color. Provision is also made for making plated stockings, *i. e.*, wool surface with cotton inside. Attachments are also provided to make a lace effect.

Setting-Up and Starting a New Machine from the Factory. It is a good practice to set the machines 13 or 14 inches apart. The belt should be nearly as wide as the pulley on the machine, and may be run from a floor shaft, or from an overhead shaft. If driven from a floor shaft, the driving shaft should have such a speed as to allow the pulleys to be 10 or 12 inches in diameter, while if driven from an overhead shaft, the driving shaft may have such a speed as to allow the use of 7 or 8 inch pulleys. The speed of the machine should ordinarily be from 240 to 265 revolutions per minute, though on some kinds of work a speed of 300 revolutions may be used.

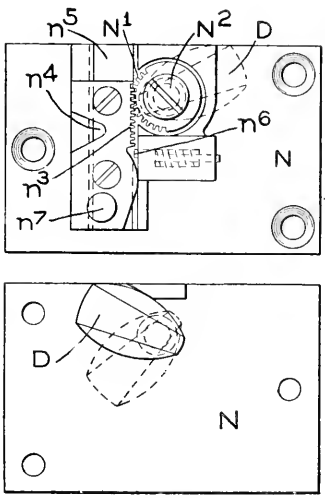


Fig. 143.

After the machine has been set in its proper place and all grease and dirt removed, see that the latches on the cam cylinder lock the dropper and lifter in place, replace the disconnected parts and connect them; then put on the yarn and lower the center block switch cam, the stem of which protrudes through the cam cylinder bracket directly under the yarn tube in the latch ring, or thread carrier. This will allow the butts of the needles to pass under the stitch cam. Turn the machine a few times by hand to be sure that everything is working properly before starting up with power on.

To Replace a Broken Needle. Raise the center block cam, so that the needles will all be on a level, and then raise the latch ring or yarn guide. Then raise the elevating cam on the cam cylinder opposite the automatic switch, set the automatic switch so that it will not pull the needles down and hold back the switch cam shifter so that it will not change the switch. Turn the machine by hand and the needles will all raise above the cams. Then pull out the plugs which hold the brass ring in place, and raise the cylinder out of machine. Take

out the broken or damaged needles and put in new ones; replace the cylinder and lock the brass ring in place. Push the elevating cam down, and push down ten or twelve needles directly above the switch cam shifter. This will allow the automatic switch room to change. Turn the machine and the needles will all go down to the level. Then drop the center switch cam.

To replace a sinker, take off the sinker cam plate, replacing and adjusting it again after replacing the sinker.

To Set a Pattern for Stockings or Hose. In starting a stocking or

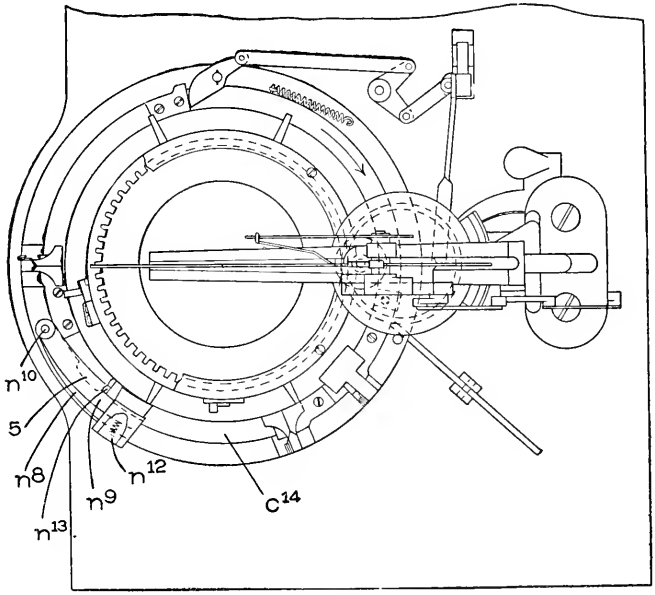


Fig. 144.

hose, the two indicators on the outside end of the pattern wheel should stand together. On the inside end of the pattern wheel are two discs or wheels. Each of these discs has a trip or pawl fastened upon it by a clamp, which can be moved back and forth by loosening the screws which hold it in place. These trips operate upon the change motion to change from the circular motion to the reciprocating motion. The inside disc is for the toe, and the second one is for the heel. Upon the side of the toe disc is a high point and an incline. The high point operates the stop motion to stop the machine when the hose is com-

plete, or to make a loose course when making a lady's hose as string work. The incline operates the stitch gauge to regulate the length of the stitch of the leg and ankle. The toe trip should be set so it will be about one and one-half inches back of this high point. This distance regulates the number of courses knit on the toe of the stocking or hose to seam or loop by, and will allow about eight or ten courses. If too much, set the trip farther from the high point; if not enough, set the heel trip nearer to the high point on heel disc about five-sixths of the distance around the disc, back of the toe trip. This regulates the length of the foot. If the foot is too long, set the trip still farther around; if too short, do not set it around so far. Always get the length of the foot by changing the heel trip, and do not change the toe trip after once getting the proper number of courses to seam or loop by.

On the outside end of the pattern wheel, are two large gears. Between these gears is a segment with three or four teeth cut in it to match the teeth in the large gear and which is fastened to the outside gear with a clamp. Loosen the clamp and set the segment back to lengthen the leg of the stocking or hose; or set it forward to shorten the leg. After setting the segment forward or backward, clamp it to the outside gear so that the three or four teeth in it will be sure to line with the teeth in the outside gear. Always feed one tooth on the pattern wheel ratchet in making ladies' stockings or hose.

To Set-Up Pattern for Socks or Half Hose. Have the toe trip in about the same position as for ladies' hose, moving it forward or backward to get the proper length to loop or seam by. Set the heel trip about opposite the toe trip or about one-half way around the disc back of toe trip, and set the segment forward or backward, as on ladies' hose, to get the proper length of leg. Feed two teeth on the pattern wheel ratchet to make socks or half hose.

To Set-Up Pattern for Footing Rib Legs for Misses' or Boys' Hose. Set the toe trip nearer to the high point than for ladies' stockings, moving it a little forward or back to regulate length to seam or loop by. Set the heel trip about one-third around the disc back of the toe trip or as far as necessary to get proper length of foot. Regulate the length of the ankle by the segment between the outside gear, and feed from four to eight teeth on outside ratchet, according to the size of hose desired. Four teeth will make about size $9\frac{1}{2}$, and eight teeth will make size $4\frac{1}{2}$.

The Operation. In describing the operation of knitting a stocking or hose upon this machine, we will represent the needles by a series of small lines as shown in Fig. 145. These needles may be said to be divided into three sets; one set, namely, those inclosed with the bracket A, extending one-half way round the cylinder; two sets B B each extending about one-sixth of the way round the cylinder on opposite sides of the same, and one set C between the sets B B. A thread is fed to all the needles, and the machine is rotated so as to produce, by round and round knitting, continuous circular courses of stitches, until the desired length of tubular fabric for the leg has been formed and it becomes necessary to form a heel.

In knitting a sock, the stitches of a short length of ribbed tubular fabric may be applied to the needle of the machine before commencing to knit the leg of the sock, so that when the sock is complete, it will have a rib top; but in knitting a lady's stocking, where no rib top is required, the needles may have a greater draft while knitting the upper or calf portion of the leg than while knitting the lower or ankle portion. After the desired length of tubular fabric has been produced for the leg, the needles A are raised so that their butts or shanks are above and free from the action of all the cams, leaving only needles B and C in action.

An extra thread, or thickening thread, is twisted to the main thread to reinforce or thicken the heel, the machine at the same time changing from rotary to reciprocating motion. The two threads are carried back and forth around that part of the needle cylinder having the needles B and C forming stitches upon them, At the end of each reciprocating motion, one of the needles B, at the end adjacent to the needles, is thrown up and out of action, first on one side and then on the opposite side, so that with each reciprocating movement, the web produced is narrowed to the extent of one needle, first on one side and then on the opposite side. This narrowing operation is continued until all of the needles B B have been thrown out of action, leaving only the needles C in action. As soon as this has been done, the needles B B must again be thrown into action for the purpose of widening. This is done by lowering two needles into action, and after knitting one course of stitches upon them, one is thrown out of action again. This is continued first on one side, then on the opposite side, until all of the needles B B have been lowered into action in the reverse order

from that in which they were thrown out of action. When this is done, the thickening thread is cut out, the needles A are lowered into action again, and the machine changed from reciprocating to rotary motion.

The operation just described is performed to produce a seamless pocket, which constitutes the heel of the stocking or hose. After the heel has been completed, knitting of the tubular fabric is resumed and continued, until it is of the length desired for the foot of the stocking or hose, thereupon, the operation resorted to in order to form the heel is repeated to form the toe.

After the completion of the toe, a few tubular courses are knit,

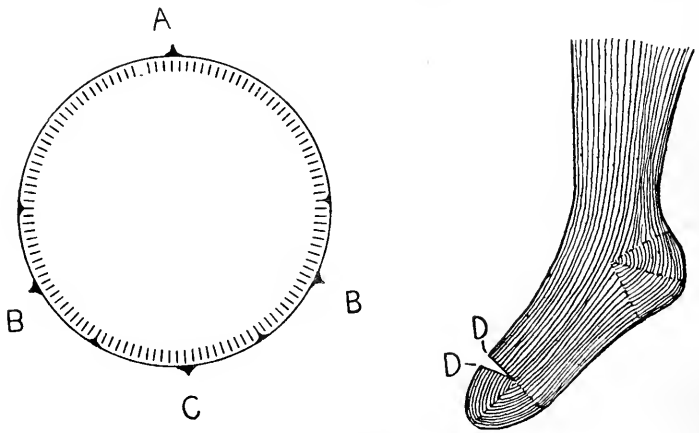
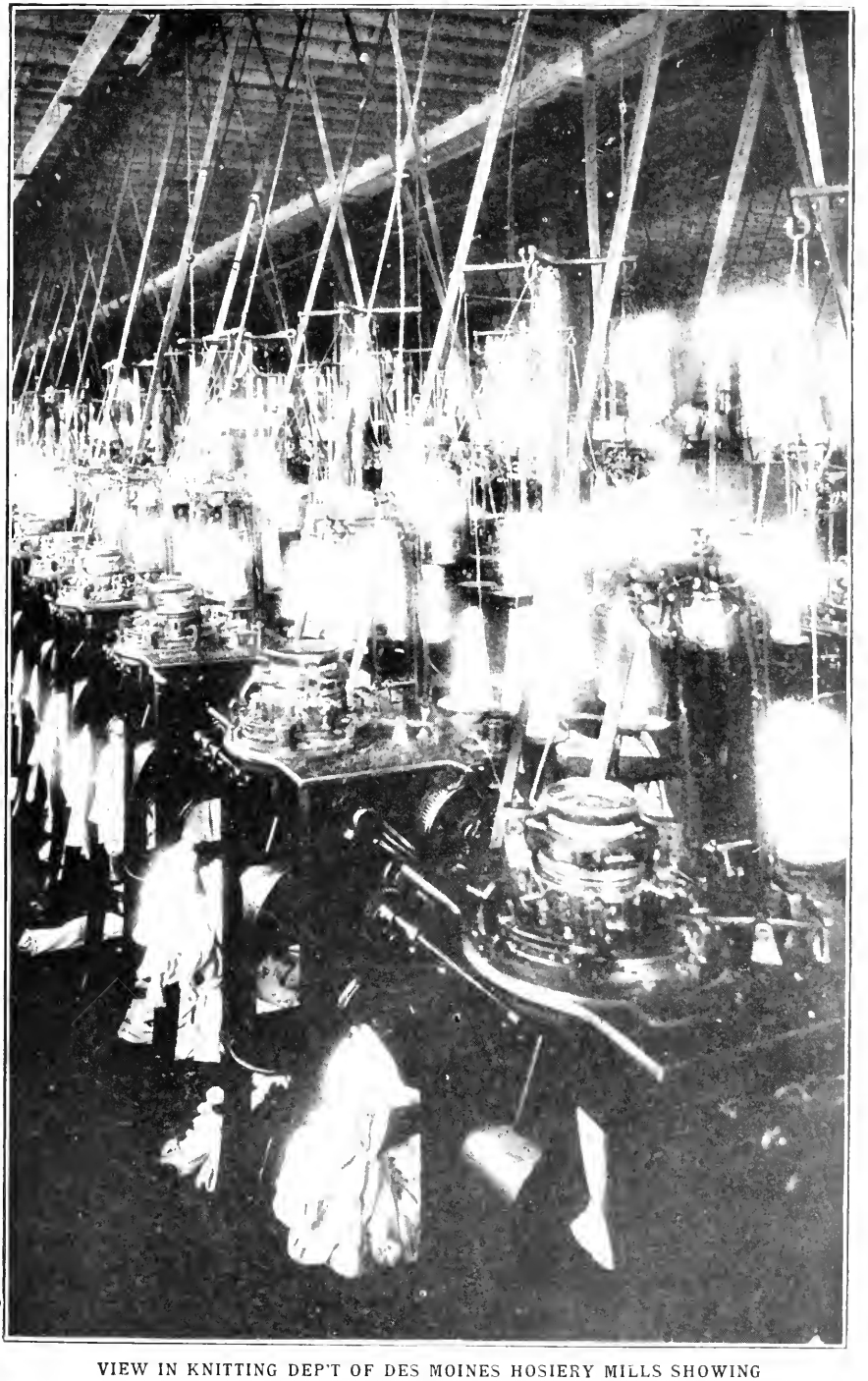


Fig. 145.

then the stocking or sock may be cast off the needles, and a new stocking or sock commenced. But if it is intended to operate the machine, to produce stocking after stocking in succession, the production of the tubular fabric may, after the formation of the toe, be continued to form the leg of the next stocking, and so on, the fabric being cut off near the toe, so that each stocking will present the appearance shown in Fig. 145, the toe being completed by uniting the edges D D in the usual manner.

THE RIBBING MACHINE

Half hose are finished with a rib top, as alluded to several times previously, ribbed fabric being very elastic and better adapted for the purpose than plain knit fabric.



VIEW IN KNITTING DEP'T OF DES MOINES HOSIERY MILLS SHOWING
ACME KNITTING MACHINES

The Rib Top Machine, or "Ribbing Machine" as it is more commonly called, is a single feed, full automatic machine with two banks of needles (dial and cylinder) designed especially for making rib tops. It is so constructed that almost any desired length of rib can be made, either very elastic or non-elastic, in a continuous string, having any desired number of welts from one to six, and an extra course of long stitches, for convenience in placing the stitches on points of what is known as a transfer, or direct on the needles of the knitting machine according to the method in use.

The ribs are cut by hand, or by a rib-cutter which the operator operates with the foot, severing the string between the round of long stitches (slack course) and the welts. These must be cut as near the welts and as straight as possible, for this represents the top of the sock. When the rib is cut off we have the rib proper. It is then placed on either transfer points or the needles of the knitting machine. In case of the former, which is in most general use, the rib is then transferred to the needles of the knitting machine by placing the hollow points of the transfer over the eyes of the needles, and lowering them until the hooks of the needles pass the stitches on the points, when the transfer can be removed, leaving the rib stitches on the machine needles.

If the knitting machine is full automatic, it proceeds with its work, making the leg, heel, foot and toe, throwing an extra thread in both heel and toe, thus producing what is termed a reinforced, or spliced heel and toe. After completing the toe, several rounds of stitches are knit on to make room for the looping, or closing of the toe on a looping machine.

The ribbing machine belongs to the Stationary Needle Cylinder class in which the needle cylinder, needle dial, take-up and fabric are stationary; and the cam ring (to which are fixed the vertical needle actuating cams), the cam dial (to which are fixed the cams for actuating the horizontal or radial needles), and crossbar, or yoke, revolve.

The ribbing machine being of smaller diameter is usually fitted with but one feed and one set of cams each for cylinder and dial. One of the sets, usually the dial set, is provided with a movable cam in order to effect the change from the plain stitch to the welt which will not ravel out, for the finish of the cuff. The welt consists of two or three courses of short stitches and is made by allowing the dial needles to project only about half the usual distance so as to hold their loops with-

out knitting; or in other words so that the loop already in the hook is allowed to slip back only far enough to open the latch and let the yarn carrier feed one or more loops into it, thus forming a separate tubular plain fabric for a few courses.

This variation of needle movement is effected by means of a movable cam which is controlled by a pattern wheel arrangement.

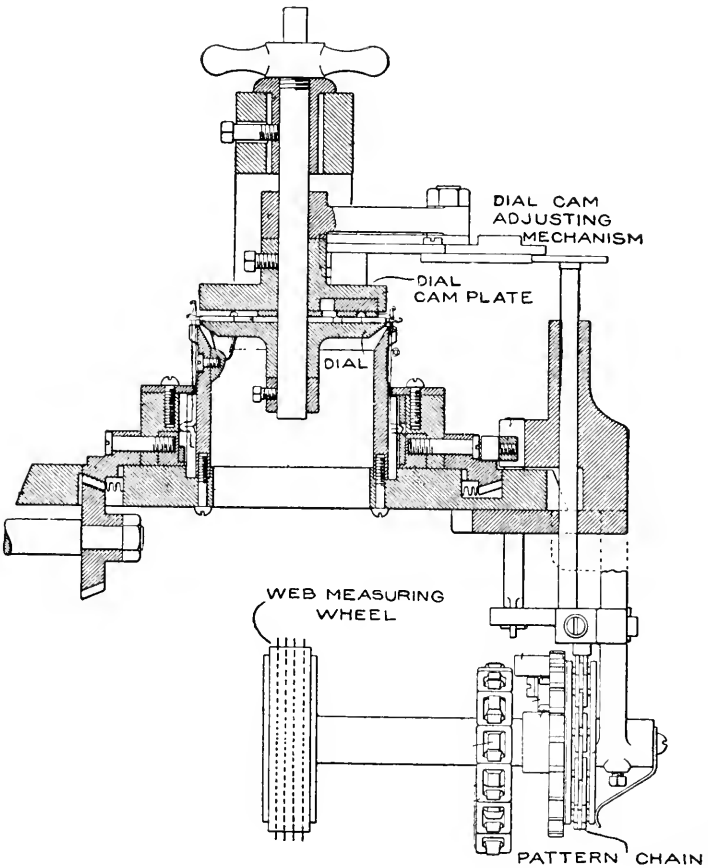


Fig. 146. Type of Rib Top Machine. Sectional View.

It is customary to knit a course of long loose stitches somewhat less than a half an inch from the welt, so that when the continuous string of ribbed tops are cut apart, the loose stitches may be easily transferred on to the needles of the stocking machine. The loose or

slack course is made in the fabric by means of the cylinder needles, actuated by a movable cam in the cam ring, which is controlled by a pattern wheel. Fig. 146 represents a type of this machine.

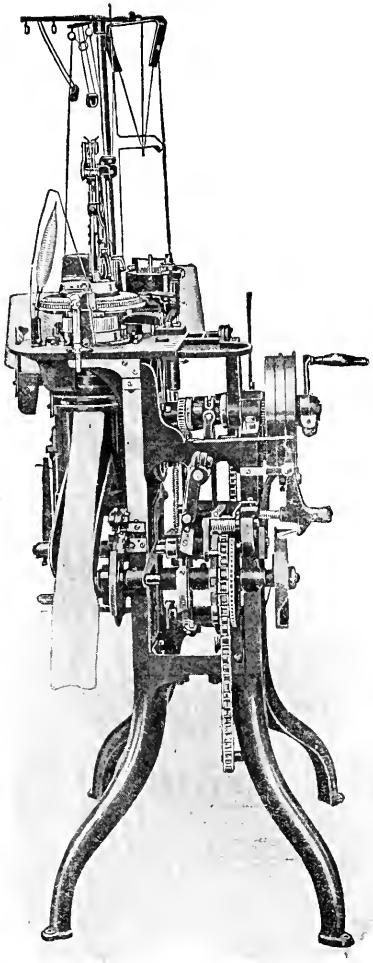


Fig. 147. Hemphill Full Automatic Machine.

HEMPHILL FULL AUTOMATIC

The machine illustrated at Fig. 147 represents another type of circular knitting machine in which web-holders or sinkers are employed with latch-needles to knit seamless stockings with heel and toe of different yarn.

Method of Driving. The bed 1 of the machine is supported by a frame 2, mounted on legs 3, as illustrated in Fig. 148, a cup-shaped bearing 4 being formed below the bed (also shown in Fig. 154).

The main shaft of the machine is represented at 7, and is provided with the large bevel-gear 8 secured thereto at one end, while the other end is mounted in a sleeve 9, to which is secured a driving-pulley 10, having a crank-handle 11 for working the machine by hand. A loose pulley 12 is mounted on an extension of the hub of the driving-pulley. Loosely mounted on the shaft near the bevel-gear 8, is a pinion 13; the inner end of the sleeve 9 is also formed as a pinion 14. Between the pinions 13 and 14 is a clutch-hub 15, with a feather to permit the hub to slide while held from independent rotation. Two projections or teeth 16, in the clutch-hub, engage a groove in one or the other of the pinions 13 and 14; and an angular groove 17 receives pins or rollers 18, carried by a shifting yoke 19, which is secured to one end of rock-shaft 20 (see Figs. 149 and 165) mounted in a bearing 21.

A gear 22 (see Figs. 148 and 149) is mounted in a bearing supported by the frame and meshes with pinion 14, and is constantly driven thereby during the operation of both the round-and-round work and heel-and-toe knitting operation. To crank-pin 23 (see Fig. 148) is connected one end of a pitman 24, the other end being connected with one end of an elbow-lever 25, mounted on a shaft 26, supported in standards 27. The other end of the lever 25 is provided with a segmental gear 29 which meshes with pinion 13 on the main shaft (see Figs. 148, 149, and 154).

When the clutch-hub is in engagement with the pinion which is constantly driven, the gear will move continuously in one direction. During this time the segmental gear is imparting a rotary reciprocating motion to the pinion which is loose on the shaft; but when the clutch-hub is shifted to engage the loose pinion, it is disengaged from the constant pinion, which latter then imparts to the shaft and to the gear 8 a rotary reciprocating motion. The motion of the elbow-lever imparts movement to the pattern-chain and to certain cams, through the medium of pawls.

Pattern Chain. A shaft 30 is mounted in bearings 32 (Fig. 149) supported by the frame. Loosely mounted on this shaft is a ratchet 33, to one side of which is secured the pattern-chain pulley 34 (see also

Fig. 164), the pulley having teeth to engage the links in the pattern-chain, some links having lugs 36. The ratchet and pulley are driven in the direction of the arrow shown in Fig. 162, by means of a pawl 37 connected with one end of an elbow-arm 38 (see Fig. 148) mounted on shaft 26, the other end of the arm being secured to the side of the elbow-lever by means of a bolt. A bracket 41 is secured to the frame of the machine (see particularly Fig. 149); and bolted to this bracket

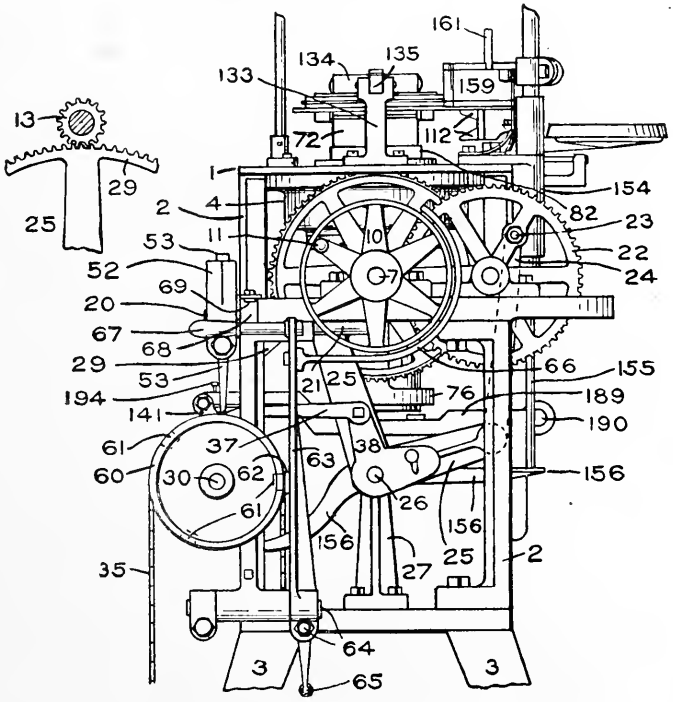


Fig. 148.

is a shield 24, on which the pawl rides during a portion of its stroke. The shield is secured to the bracket with a bolt to adjust the amount of feed imparted to the pattern-chain. A ratchet 43 (see Figs. 163 and 164) is secured to the shaft 30 on the opposite side of the pulley 34; and this cam-driving ratchet is intermittently rotated by means of a pawl 44 when permitted by the lugs of the chain. The pawl 44 is also connected with the elbow-lever 25, and is reciprocated thereby. The shield is pivoted on a pin 46, carried by the bracket and extending

over both ratchets and chain-pulley, and is provided with an arm 47, having a pin 48, which projects into the path of movement of the chain-lugs. A spring 49 is coiled about the pin 46, and tends to hold the arm and shield in position; but when a chain lug raises the pin, the shield is depressed, the pawl engages a tooth of the ratchet, advances the latter, and partially rotates the shaft and the cam-discs.

One complete rotation of the shaft 30 and its cams takes place

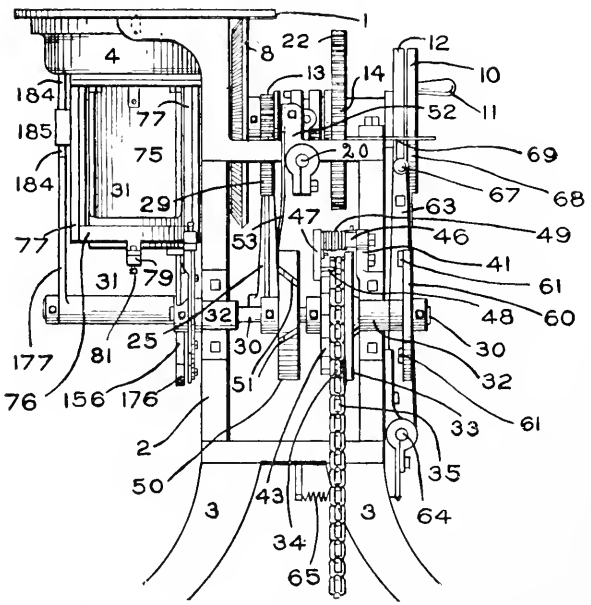


Fig. 149.

during the knitting of one stocking, the length of the article and its shape being controlled by the length of the chain employed and the spacing and number of lugs carried by the chain. The knitting operation itself continues uninterruptedly without regard to the rotation of shaft and cams; but when a stocking is finished, the rotation of the shaft effects the automatic stoppage of the entire knitting operation; and, during the single rotation of the shaft, it also effects two temporary shafts of the driving-belt, to slow down or ease off the machine when the clutch-hub is moved into engagement with the pinion 13. This movement of the hub changes the knitting from circular or round-and-round work to the narrowing or widening at heel or toe, one-half

of the needles being thrown out of action. During the narrowing or widening the knitting-cams have a rotary reciprocating motion through the segment and other gearing; and to change to this motion from the continuous rotary motion, another mechanism is provided.

Changing the Motion. At one end of the shaft 30—the right-hand end (Figs. 148 and 149)—there is secured a disc 60, having three cam-lugs 61 on its side, near the edge. These operate successively against a pin or roller 62, carried by a lever 63, pivoted at 64 to the

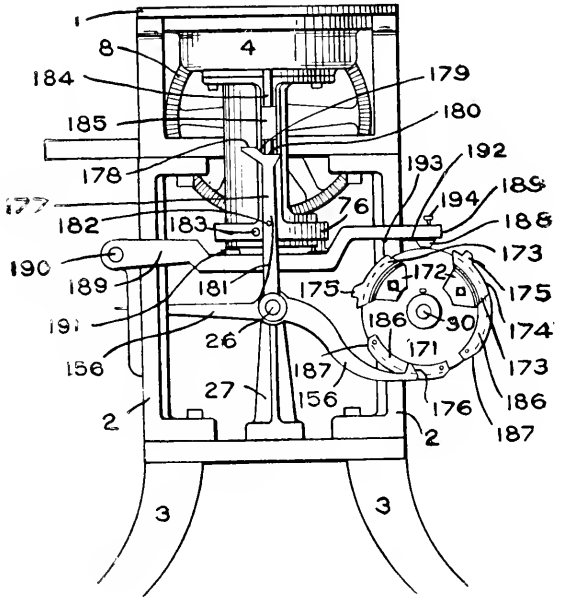


Fig. 150.

frame of the machine, the lower end of the lever being acted on by a spring 65 to keep the pin or roller in engagement with the cam-disc. The upper end of the lever 63 carries a belt-guide 66 for shifting the belt when cam 61 acts on the shipping lever.

The lever is provided with a handle 67, and with the finger 68, which moves under and is held by a spring-latch 69 secured to the frame (see Fig. 149) whenever the lever 63 is moved to its limit of motion for throwing the belt off the fast pulley. One of the cams 61 on the disc 60 is of a height sufficient to throw the lever to this limit of movement, so that the lever is retained by the spring-latch and the

driving-belt held on the loose pulley, thus stopping the machine. To start the machine, lift the spring-latch and permit the spring to cause the belt-shipping lever to restore the belt to the fast pulley; the movement of the disc which caused the lever to be caught by the spring-latch carries the cam-lug just beyond the roller of the lever. The other two cam-lugs cause the lever to shift the belt onto the loose pul-

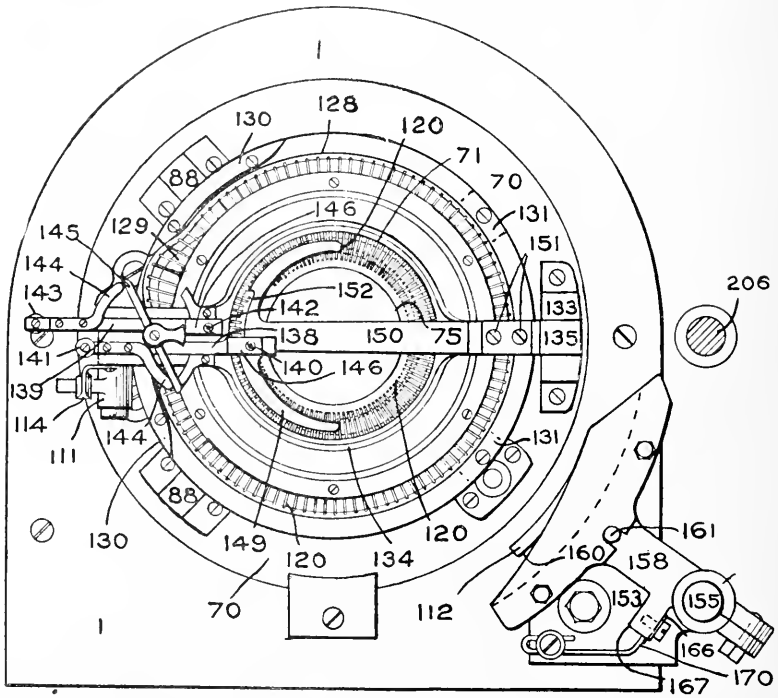


Fig. 151.

ley, but not to be engaged by the spring-latch, so that the power is thrown off the machine momentarily, at the moment when the change in the knitting above described is taking place. The cam-lugs operate the lever and pass beyond it during the time that the pawl is making one stroke to partly turn the shaft and its cams, the belt barely passing off the fast pulley before it is shifted back again.

The Needle-Cylinder. The needle-cylinder 72 extends through a central opening in the cam-ring (see Fig. 154), and rests upon an annular shoulder 74 formed upon web-guide 75. The upper end of the

web-guide extends within the needle-cylinder; and the lower end is steadied within ring 76, supported by two rods or bars 77, which depend from the bottom of the cup-shaped bearing 4. The ring 76 has a projecting lug 78 (see Figs. 149 and 150), to which block 79 is secured by means of a bolt. A stop 81 extends vertically through the inner end of the block and projects above it. The web-guide 75 rests on the stop, except when raised for lengthening the stitch; and it supports the needle-cylinder by means of the shoulder 74. The stop being adjustable in the block 79, the needle-cylinder may be adjusted to alter the length of stitch.

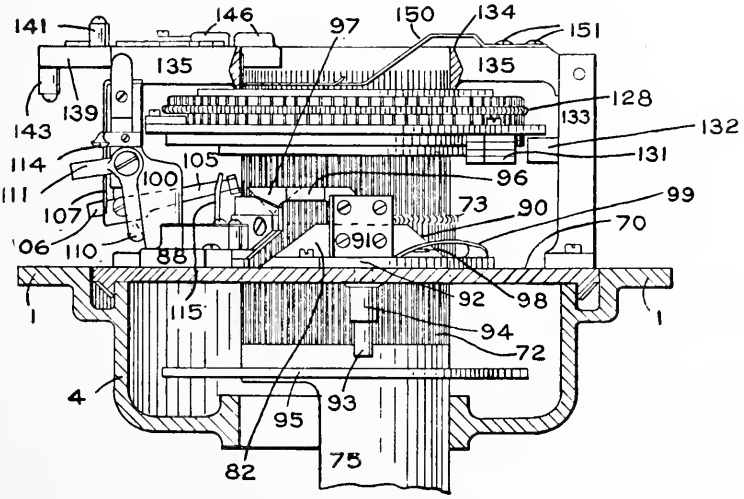


Fig. 152.

The Knitting Cams. A cam-web 82 which forms about three-fourths of a circle (see Figs. 152, 153, 154, 157, and 158), is formed at each end with an incline or cam 83, and is secured to the ring 70. The cams 83 act on the heels of the needles to raise them during the knitting operation, the heels riding on the top of the web after being raised until acted on by one of the draw-cams. During straight or round-and-round knitting, but one of the cams 83 acts; but on heel-and-toe work, when the cams are all given a rotary reciprocating movement, the two inclines or cams 83 act alternately to raise the needles. The two draw-cams 84, to lower the needles and draw the loops of yarn, face in opposite directions, toward each other. Each cam 84 is formed on the

end of a block 85, which is secured to a plate 86 on the inner end of a slide 87, fitted to reciprocate in a direction radial to the needle-cylinder in a guide-block 88, secured to the ring 70. A spring 89, is confined between the outer, closed end of the block 88 and the slide. The upper, as well as the lower, surfaces of the cams are inclined, the function of the upper inclines being to complete the raising of the needles after they have been acted upon by the picking-finger in heel-and-toe work. The faces of the blocks are flat; and when one of the cams is traveling backward around the needle-cylinder, it rides over the outer

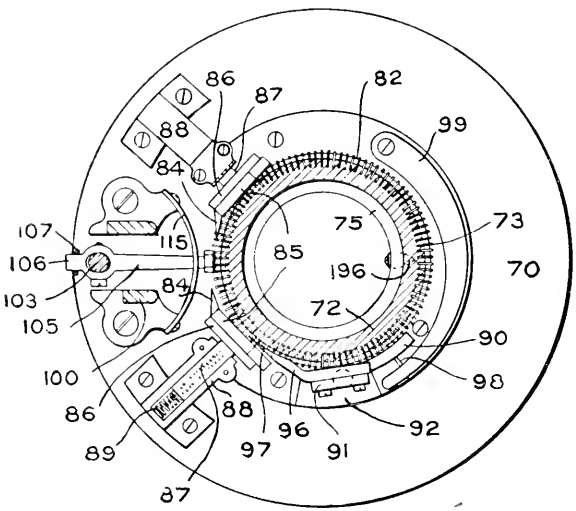


Fig. 153.

ends of the heels of needles, the spring permitting the entire block and cam to be moved outward. During heel-and-toe work the rotary reciprocating motion of the cam-ring causes first one cam to operate, the other being pushed away; and *vice versa* on the reverse movement.

Heel and Toe. Practically one-half of the needles have heels longer than those of the other needles. The long-heel needles are thrown out of action and remain so during the heel-and-toe work. Cam 90 (see Figs. 152 and 153 in connection with Fig. 154) travels in a plane entirely below the needle-heels during circular or round-and-round knitting, but is raised when the change to heel-and-toe work begins. It is secured to a block 91, rising from a segmental plate 92, which fits in the flange of the cam-web 82, and is provided with a pin 93, extending down through the cam-ring 70 and through a long tubu-

lar bearing 94, depending from ring 70. The lower end of the pin 93 is acted upon in a vertical direction by a circular plate 95 within the cup-shaped bearing 4.

The block and cam are prevented from rotating on the axis of the pin by the inner edge of the segmental plate. When cam 90 is elevated it will elevate the long-heel needles, thus carrying them out of position to be operated by the draw-cams. The block has also secured to it an arm 96, having a throw-in cam at the end. This cam,

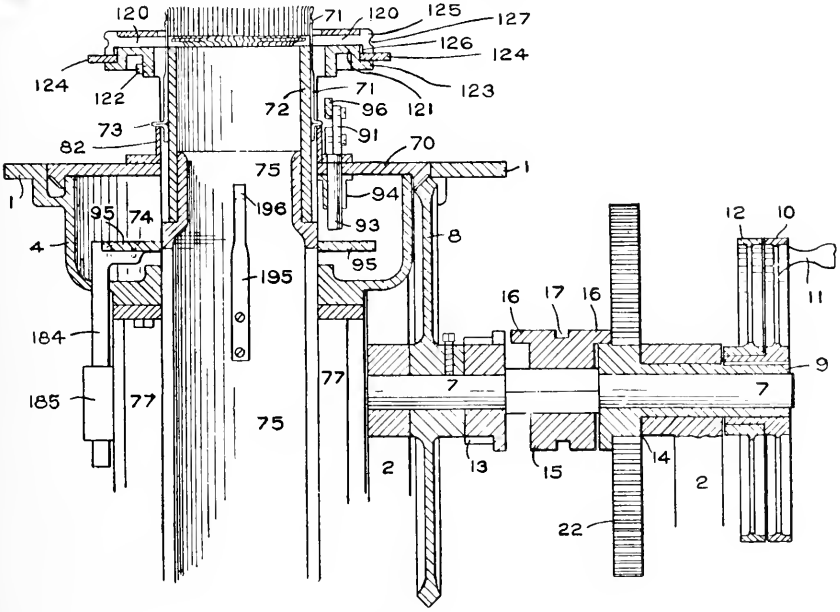


Fig. 154.

when lowered, engages the tops of the long heels and one short heel; and when the block is lowered at the end of the heel-and-toe work, it sweeps over the long heels and the single short heel, and lowers the needles to position for circular work. A pin 98 projects from the cam 90, and is engaged by the outer end of a spring 99, the other end of which is secured to the flange of the cam-web 82. The spring acts to depress the block and cams when permitted by the descent of plate 95.

Picking. The cup-shaped bearing 4 supports the cam-ring 70, which meshes with the teeth of the bevel-gear 8. This cam-ring is revolved continuously to produce circular or round-and-round work,

or is given a rotary reciprocating motion to produce heel-and-toe work. While doing the latter, practically one-half of the needles are first thrown out of action; and a portion of the remaining needles are then thrown out of action one by one to narrow, being restored in the reverse order to widen.

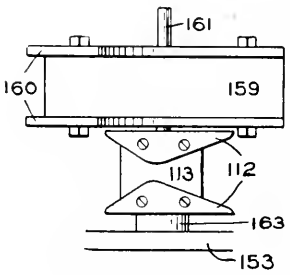


Fig. 155.

The Picker. Mounted on the cam ring, and rotating therewith, is an arched standard 100, provided with an offset 101, in which is a vertical bore or recess 102 closed at the top (Fig. 158). A plunger 103 is fitted to slide and oscillate on its axis within the recess, and is pressed downward by a spring 104, confined between the plunger and the top of the recess. To the lower end of this plunger, the picking-finger 105 is pivoted, the plunger affording a support for the picking-finger and yielding vertically against the pressure of the spring 104; and the outer, short end or heel 106 of the finger is held between two springs 107 secured to the standard or offset (see Fig. 160). These springs have a tendency to hold the picking-finger and the plunger in such position that the finger is radial to the needle-cylinder, but permit these parts to swing to either side of that position. The acting end of the picking-finger is shaped somewhat in the form of an equal-armed cross (see Fig. 167), with two vertical lugs 108 and two horizontal lugs 109. Fulcrum 110 consists of a horizontal arm, having a sharp upper edge projecting from an elbow-lever 111 pivoted to the side of the standard-offset 101. The cams 112 have no movement other than a vertical one. As the outer end of lever 111 sweeps around between them, it comes in contact with one or the other, according to the elevation of the block 113 and the cams, and causes the fulcrum-arm to shift its position. The movement of the fulcrum in one direction is limited by its coming in contact with the outer side of the standard 100, and

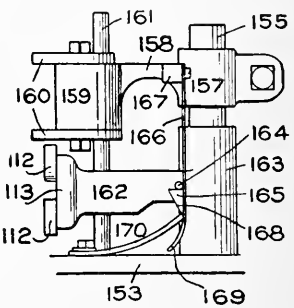


Fig. 156

in the other direction by a stop 114 secured to one side of the offset 101, as shown in Figs. 152 and 160. To the feet of the standard 100 is secured a curved plate 115 (see Figs. 153, 157, 158, and 159) having an opening through which the picker extends. When narrowing is to be commenced at the heel or toe, and after the cam 90 has raised all of the long-heel needles out of action, the block 113 is raised, and the lower cam 112 throws the picking-finger 105, into the position shown in Fig. 157. At the same time, the motion of the cam-ring is changed from a continuous rotary to a rotary reciprocating movement, during which movement neither cam 90 nor cam 97 performs any function. As one side of the upper lug 108 of the picker comes in contact with the side of the butt of the first needle of the remaining series of needles, the end of the picker is stopped; but since the cam-ring continues to

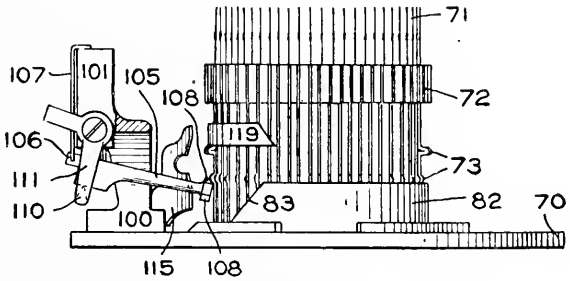


Fig. 157.

move, and with it the standard and cam-plate, one of the lower cams 117 of the plate rides under the finger and elevates it, thus causing the upper surface of one of the lugs 109 of the picker to throw that needle up out of action. As the finger finally rides into the slot 118 of the plate 115, the swinging of the finger causes the lugs of the finger to leave the butt of that needle. As soon as the finger leaves the needle, the springs 104 and 107 cause it to assume the position indicated in Fig. 157, ready to engage and elevate a needle at the other end of the series.

When the needles are to be brought back again into action one by one for widening, the block 113 is lowered, and the upper cam reverses the position of the elbow-lever 111, moving the picker to the position shown in Figs. 151 and 152. Then the lower lug 108 of the picker, and the under surfaces of the lugs 109, act on the butts of the needles

one by one to depress them under the influence of the upper cams 116 of the plate 115. When all of the short-heel needles except one at each end of the series have been rendered active the block 91 is lowered and the first complete rotation of ring 70 causes the cam 97 to throw in all of the elevated needles, which are the long-heel needles, and the two remaining short-heel needles; round-and-round work is automatically resumed. The reason for throwing in the last two fashioning needles simultaneously with the long-heel needles, is to avoid leaving a small hole in the fabric each side of the heel. When all of the needles are down, the picking finger engages none of the heels, for it is then in the position shown in Fig. 152, the block 113 and the cams 112 being lowered.

Sinkers. The web-holders or "sinkers" which co-operate with the needles and prevent the lifting of the web by the upward movement

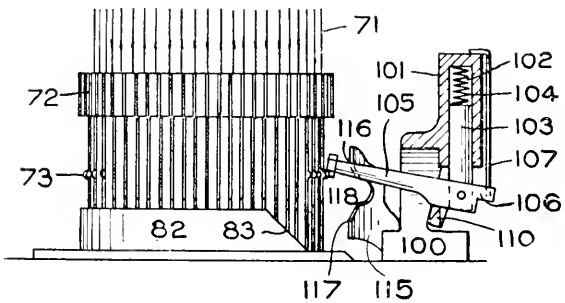


Fig. 158.

of the needles, and which also help to draw the stitch, are indicated at 120 (see Figs. 154 and 166 in connection with Figs. 148, 151, and 152). They are supported in radial grooves in a bed 121, which is secured to the needle-cylinder by screws 122, the bed having a horizontal flange 123, which forms the bearing for a ring 124 carrying the cams for reciprocating the web-holders. Each web-holder has an upper shoulder 125, to limit the inward movement, and a lower shoulder 126, which permits the cams carried by the ring 124 to withdraw the holder. The outer ends of the web-holders are notched, as at 127, to receive an elastic band 128, consisting of an endless coil of fine steel wire, which acts on all the web-holders to hold them inward and prevent their being thrown out by centrifugal force.

The cams carried by the ring 124 are shown in Fig. 151, in which

129 represents the double-ended cam for engaging the inner sides of the shoulders 126 for moving the web-holders outward during either direction of movement of the ring, and 130 represents the two cams also carried by the ring 124 for engaging the outer ends of the web-holders to retract them, aided by the action of the endless spring 128. Secured to the underside of the ring 124 are two blocks 131, the positions of which are indicated by dotted lines in Fig. 151, and between which a striker 132 extends, the striker projecting from a standard 13 (see Fig. 152) which rises from and rotates or oscillates with cam-ring 70. When cam-ring 70 is revolving continuously, the striker engages but one of the blocks 131; but when oscillating, the striker engages the two blocks alternately and reciprocates the ring. The space between the two blocks 131 corresponds somewhat with the space between the knitting-cams, and permits of the web-holders and needles remaining at rest while the picking-finger is changing its position. By pulling away the spring-band 128, either entirely or for portions at a time, the web-holders can be easily withdrawn and replaced by others, if desired; or those which are used most continuously may replace those which are less worn on the other side of the machine, and *vice versa*.

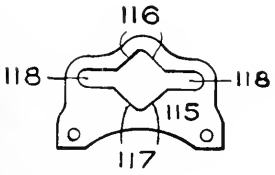


Fig. 159.

The *latch-guard ring* 134 (see Figs. 151 and 152) can be swung up out of the way whenever desired, as when placing a new cuff on the needles or to enable the needles to be more readily examined, without removing it from its support by the cam-ring 70.

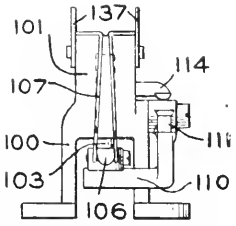


Fig. 160.

The *yarn-changing devices* are carried by the arm 135. The upper surface of the outer end of the arm 135 is formed with guideways (Fig. 151) for two slides 138 and 139, one having a yarn-guide eye 140 at its inner end and a pin having a roller 141 at its outer end, and the other slide having a yarn-guide eye 142 at its inner end and a downwardly projecting pin having a roller 143 at its outer end. Each slide is provided with a projecting arm 144, against which bear the ends of a lever 145.

Lever 145 is pivoted to the guard-ring arm between the two slides; and when one slide is pushed in, its arm pushes the other slide out. The inner ends of the slides each have a stop 146, to limit their outward movement.

The curved web-guide 149 (see Fig. 151) is formed at the outer end of a spring-arm 150, secured to the arm 135 back of the latch-ring, as indicated at 151 in Fig. 152. A recess 152 is formed in the edge of the web-guide, having hooked ends to retain the yarn which is not being knitted in position for use again when the next change is made.

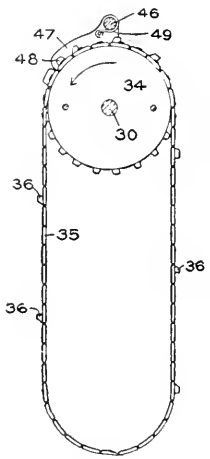
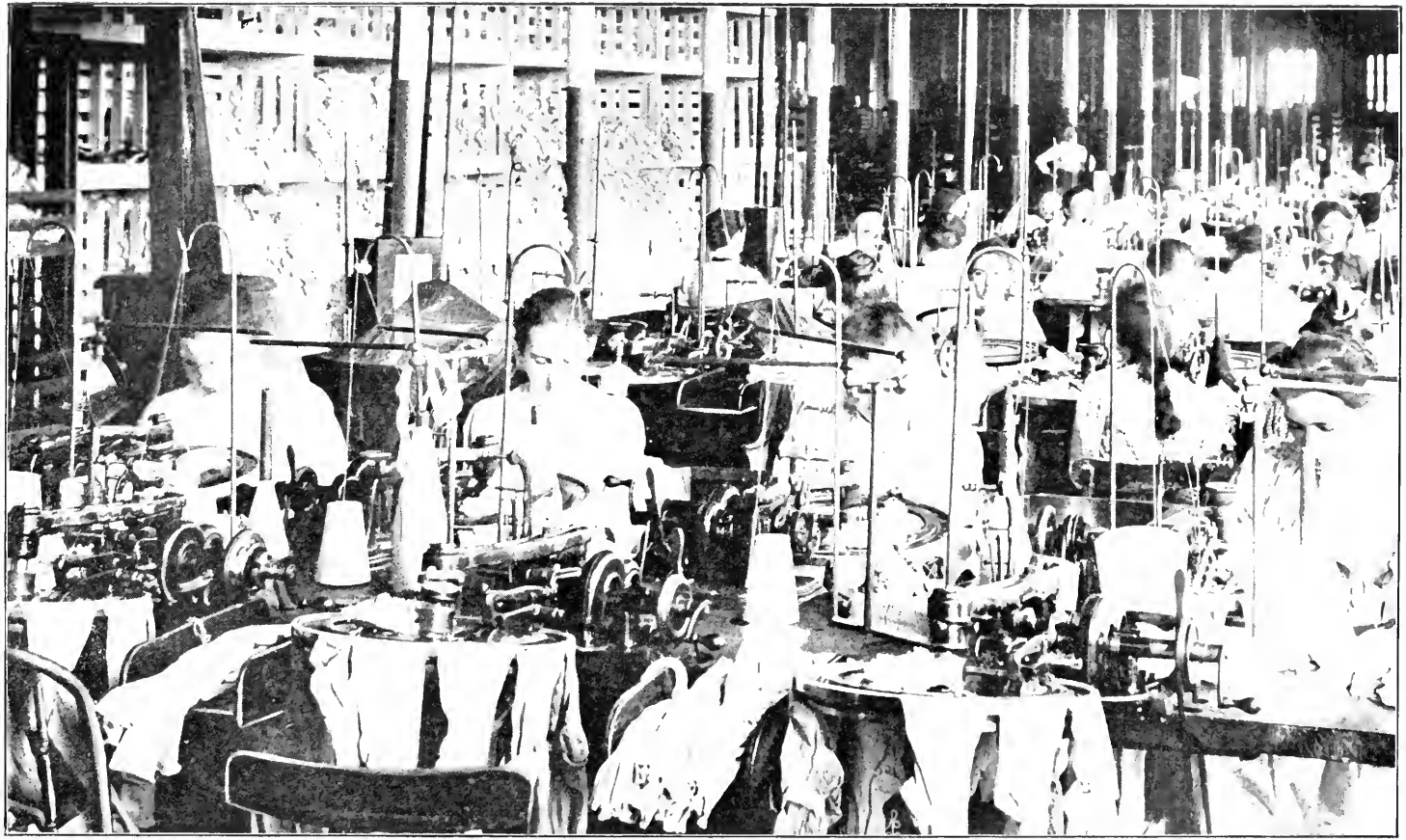


Fig. 161.

Changing Yarn. A plate 153 is secured to the bed 1 of the machine, and has a vertical sleeve-bearing 154 extending over and below the bed (see Fig. 148). This bearing is for a lift-rod 155, the lower end of which bears upon and is operated by a lever 156. To the upper end of the lift-rod is secured a sleeve 157, having an arm 158, carrying a block 159, to the upper and lower surfaces of which are secured plates having cam-shaped edges 160. Cams 160 are so spaced that one or the other of the rollers of the yarn-changing slides will sweep between them when no change in the yarn is to be effected; when the yarn-guide slides are to be shifted, the lift-rod is acted upon by the lever to raise the block and bring the lower cam into the path of movement of the roller, which, moving over the edge of the cam, reverses the positions of the guide-eyes. When the yarn-guides are to be shifted back again, the rod is lowered to position and changes the yarn.

Changing Operation of the Picking-Finger. The block 113 (Fig. 156) carrying the cams 112, is supported by an arm 162 projecting from a sleeve 163 loosely mounted on the lift-rod. The guide-pin 161 passes through the arm 162 to steady it, as well as the block 159. A pin 164 projecting from the arm 162, is engaged by a lug 165 carried by a spring 166, the upper end of which is secured to a lug 167 projecting from the arm 158. The side of lug 165 is inclined, as 168; and below this incline the lower end of spring 166 is curved or inclined, as at 169, under the end of a finger 170 fixed to the plate 153. The cams which act on the lift-rod impart two elevations to it for each narrowing



VIEW IN LOOPING ROOM OF SHAW STOCKING CO., SHOWING OPERATIVES CLOSING TOES ON BEATTIE LOOPERS

and widening operation, during which time the yarn is changed. The first lift of the rod elevates the block and cams and changes the yarn as above described. At the same time, block 113 is elevated, and this brings the picking-finger into operation for narrowing. The timing of the operation of other parts is such that simultaneously the needles having the long heels are thrown out of action, and the rotary reciprocating motion of the knitting cams takes the place of the continuous motion. When the narrowing is completed, the lift-rod is given a short elevation above the plane of the first, giving to the arm what may be termed a "hitch." This is but momentary; but it serves to draw the curved lower end of the spring upward, over but not entirely above the end of the fixed finger, which pushes the spring outward sufficiently to carry the lug out from under the pin of the arm. The arm and its block and cams immediately drop, and cause the operation of the picking-finger to begin restoring the needles for widening. The second elevation or hitch of the lift-rod is for this purpose only, and the position of the cams is not so changed as to shift the yarn-guides, for the same yarn is used in widening as in narrowing. Simultaneously, however, with the resumption of continuous rotary motion of the knitting cams, and the restoration of all the needles to positions of activity, the lift-rod descends to its normal position, and the upper cam effects the change of the yarn to the color and quality preferred for the round-and-round work; and the inclined lower side of the lug rides down over the pin, the lug then snapping under it, ready for the next operation. The picking-finger is left turned upward; but, there being no needles with their heels in a plane to be engaged by the finger, the latter remains out of operation until the next change.

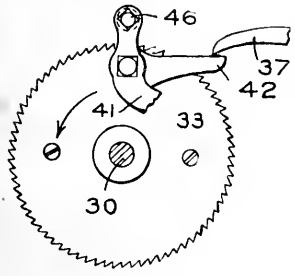


Fig. 162.

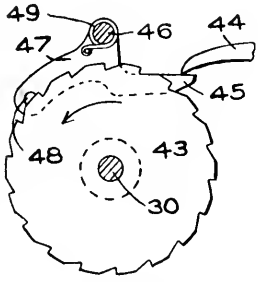


Fig. 163.

The **lift rod** is secured to shaft 30 at the opposite end from belt-shipping disc 171, to which two sets of cams are attached (see Figs.

149, 150, and 164). To this disc are attached two similar ears 172, the operative surfaces of which are offset.

The lever 156, which operates the lift-rod, is pivoted on shaft 26, and has its front beveled end 176 in the path of movement of cams 173 and 175. Cam 173 imparts the first elevation to the lift-rod, while cam 175 gives it the second elevation or hitch before referred to, after which the end 176 of the lever passes to the short section of plate 172 behind cam 175, and at the next advance of the disc it passes off the plate and to the position shown in Fig. 150.

Connected with the lever, so as to oscillate therewith, is an arm 177, having its end formed with two steps 178, 180, connected by an incline or cam 179 (see Fig. 150). A spring 181 secured to the bearing

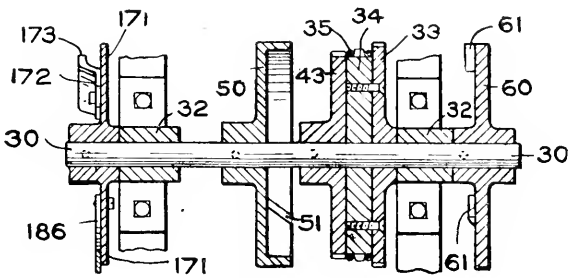


Fig. 164. Cam Shaft.

for lever 156 and arm 177, bears against a pin 182 projecting from the arm, and tends to hold the arm and lever in the position shown in Fig. 150, a stop 183, projecting from ring 76, serving to limit the movement of this lever and arm toward the left.

The circular plate 95, which rises and falls to control the action of cams 90 and 97, is secured to a rod 184, which slides vertically through an opening in the cup-shaped bearing 4 (Fig. 154), and in a guide 185 carried by one of the bars 77. The lower end of slide-rod 184 rests on upper end of arm 177, and, as the latter oscillates, passes from step 178 to step 180 over the incline 179 (Fig. 150) or *vice versa*. The action of these parts is so timed that the circular plate is elevated to render inactive the needles having the long heels simultaneously with the first elevation of the lift-rod by cam 173, which causes the change of yarn and the commencement of operation of the picker-finger; but when the lift-rod is given its second elevation or hitch by

means of cam-lug 175, the step 178 simply moves slightly across the lower end of the slide-rod without affecting the elevation of the circular plate. The disc carries also two segments 186, each having a cam-surface 187 at one end to act upon a block 188 carried by a lever 189 pivoted at 190 to the frame of the machine, and having a lug 191 adapted to bear against the lower edge of the web-guide 75 when the latter is to be lifted to elevate the needle-cylinder. In order to adjust the amount of elevation that may be imparted to the web-holder and needle-cylinder by the cams, the block 188 is adjustably connected with the lever 189.

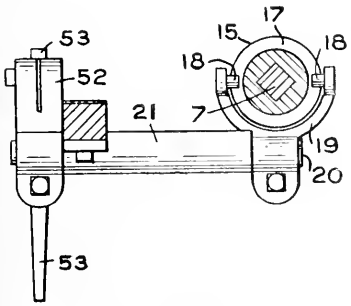


Fig. 165.

The needle-cylinder rests upon the shoulder 74 of the web-guide 75 (see Fig. 154). The upper end of the latter is surrounded by the needle-cylinder, and the cylinder can be rotated upon its seat if not locked. A yielding lock for securing the needle-cylinder to the upper end of the web-guide is shown in Fig. 154, consisting of a spring-bar 195, secured to the inner wall of the web-guide and having a wedge-shaped lug 196 at its upper end, which lug extends through an opening in the web-guide and into a tapered recess in the inner wall of the needle-cylinder. The upper end of the bar rests in a vertical groove in the inner wall of the web-guide, and the bar and its lug form a lock to prevent rotation of the needle-cylinder on the web-guide. Should a needle offer an obstruction to the passage of a cam, or if for that or any other reason such an obstruction is caused as might break a cam or break away the ribs of the cylinder between the needles, the inclined side of the recess will act on the side of the lug and force it inward, thus unlocking the cylinder from its support and permitting it to rotate.

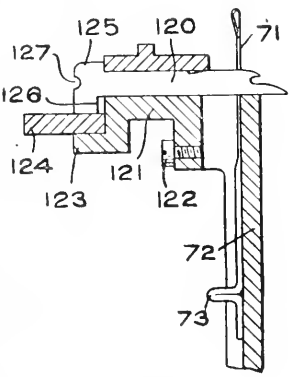


Fig. 166.

By loosening one screw and turning in the other, the bar is rocked on its lug as a fulcrum, and thus forces the other lug more or less into the recess of the needle-cylinder.

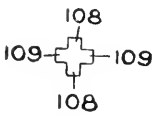


Fig. 167.

The Process. The cuff *a* is placed on the needles by means of a transferrer, and circular knitting at *b* (Fig. 168) proceeds to the point *c*. Then narrowing begins, and continues to the point *d*; and from there the knitting widens to the point *e*, when circular knitting is resumed to form the foot portion *f*. At *g*, narrowing again begins, and continues to the point *h*, whence it again widens to the point *i*, when, after knitting a few courses, the machine automatically stops. The operator then breaks off the yarn, and, by means of the crank 11, turns cam-ring 70 one revolution forward, which disengages the needles from the stocking, so that it may be removed. He then moves the crank backward slightly, which, through the engagement of the

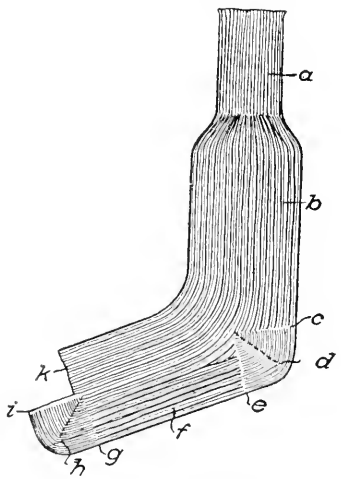


Fig. 168.

heels of the needles with the inner face of the block 85 last in operation, forces the block out of operative position and permits the cam 83 to raise the needles so that their upper ends will be on a level, in position to receive another cuff. In other words, the needles are leveled in the upper knitting-path. After the stocking has been removed from the machine, the edges *i* and *k* are united in the usual manner.

FANCY HOSIERY

When it is desirable to reinforce stockings, particularly children's stockings, at several points—such as the heel, the toe and the knee—a second or thickening thread is introduced with the main thread, the two being fed to the needles as one. If the same length of stitch be maintained in the thickened part as in the other part, the fabric is made closer, harder and less elastic. It is therefore desirable to lengthen the stitch at the points where the thickening occurs. A desirable method of introducing a reinforce just above the heel, is to throw out of operation about one-fourth of the needles at the rear at this point; knit reciprocatingly on the remainder, raising a needle at each reciprocation until one-half the needles are out of operation; and then introduce a reinforcing thread and knit reciprocatingly on the needles originally out of operation, adding a needle at each reciprocation until about one-half are in operation. By this method, the junction line between the ordinary and the thickened portion extends diagonally upward.

The *well-known split-foot hosiery* was originally produced upon a circular, independent-needle machine, the peculiarity of which lay in the fact that instead of forming the leg portion by rotary knitting, the cam cylinder was reciprocated throughout, being supplied on opposite sides with yarn-guides and knitting cams, each yarn-guide feeding yarns to, and each set of knitting cams acting upon, one-half the needles only. The result is that each yarn forms a course of stitches extending half-way around the stocking. Where these half-courses meet, at opposite sides, the stitches are interlooped. In this manner the back of the stocking may be of one color and the front of another, or the foot only may be of contrasting colors. In hosiery to be worn with low shoes, it is customary to make the lower part of the foot and the lower portion of the heel of one color, say white, and the upper part of the foot and the entire leg portion of a contrasting color. It is obvious that the half-courses of different colors may be interlooped in the same vertical wale, or that they may be interlooped in different wales according to a predetermined pattern, as shown in the accompanying illustration (Fig. 169).

A split-foot stocking may be formed upon a circular machine, by feeding one of the threads to the needles in the usual manner, a little more than half-way around the needle-cylinder, and then drawing it inward while passing the remainder of the needles. At a point a

little in advance of that where the first thread is withdrawn, the second thread is introduced and is fed to those needles from which the first is withdrawn, and is itself withdrawn after being fed to one-half the needles. After the stocking is finished, it is necessary to clip out the float threads. A stocking knitted after this fashion may be produced more rapidly than by the method first described.

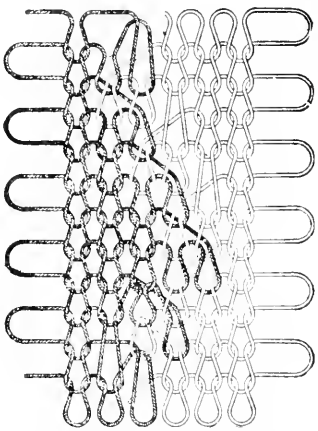


Fig. 169. Pattern Effect with Contrasting Colors.

In still another plan, by circular knitting, each course is knit as follows:

One of the threads—say the black thread—is fed first to the needles; and knitting therewith proceeds until a half-circle or thereabout has been completed and the point is reached where it is desired that a suture shall begin. The white thread is then introduced; and for a few needles—say two—both threads are knit simultaneously. Then the black thread is thrown out, and knitting proceeds with the white thread alone until the opposite suture begins. Then the black thread is again thrown in; and for two needles both threads are knit with simultaneously, as on the opposite side. The white thread is then thrown out, and knitting with the black thread alone proceeds, at which point the operation begins to repeat itself. The throwing in and throwing out of the threads must be accurately timed, so as to occur for each course between the same needles. In this way a suture is formed at each side by the interlapping threads, always on the same needles. When the thread is thrown out of the needles, it is allowed to float across the tube to the point where it is again thrown in. The number of needles forming the suture by simultaneous knitting with both threads may vary according to fancy. After the completion of the knitting of the stocking the float-threads are removed by being cut from the interior of the tube. The foot thus produced has its upper portion entirely knit from one thread, its lower portion entirely knit from another thread, and sutures at both sides knit with both threads, the courses thus formed in regular alternation being continuous, as in round-and-round knitting. Although the two portions thus formed

are not actually interknit, yet the suture formed by loops interlapping for the space of two loops is equally strong, and cannot be opened except by breaking the threads.

An imitation split-foot stocking has been produced by knitting the stocking from yarns of one color, preferably white or undyed, then enclosing that portion of the foot that is to retain its original color, in a clamp that will exclude moisture, and finally subjecting the stocking so protected, to a dye, the result being that the leg portion and upper portion of the foot are given a color contrasting with that of the sole of the foot. In a stocking carefully treated in this manner, the line of the dye will follow the edge of the clamp very exactly, and an excellent imitation of the real split foot stocking is produced.

A very pleasing color effect for hosiery is shown in the accompanying illustrations (Fig. 170). The first of these shows a piece of ordinary knitting, all except two of the horizontal courses of which are knit with white threads. Two courses (lettered *a* and *b*) are knit with black thread. Between these two black courses are four white courses *c c c c*. If the entire piece of fabric had been plain knitting, it would therefore exhibit nothing but two black horizontal stripes on a white ground. Instead of this, at two points, loops *d d*, belonging to course *a*, have been drawn forward, so as to project longitudinally ahead of their fellow loops of the same course and into the territory of the succeeding white courses *c c*. Furthermore, the interknit loops *f f* of the course *b*, by which this forward projection of the loops *d d* is effected, are themselves drawn back behind their fellow loops by the tension of the loops *d d*, so that there is produced along the same longitudinal series of loops a forward projection of the black stripe, *a* and a backward projection of the black stripe *b*; and by the meeting of these two projections, the effect produced to the eye is that of a longitudinal line or stripe joining the two horizontal stripes.

The projected loops *d d* are ten stitches apart. To effect this, every tenth needle of the machine must be so operated that, after receiving the loops of the black course *a*, it shall be prevented from knitting during the knitting of the four succeeding courses *c c c c*. This may be accomplished by preventing these needles, during the knitting of these four courses, from rising far enough to throw the loops of the black course below their latches, and returning them into line with the rest of the needles at a point either above or below the

feeding-level. This fabric has been made by throwing them in at a point *above* the feeding-level. Consequently the threads *c c c c* of the four succeeding courses have all been laid in the hooks of the inactive needles without being interknit with each other. When the work has progressed as far as the course *b*, these needles are again thrown into ordinary action, and, having taken within their hooks the

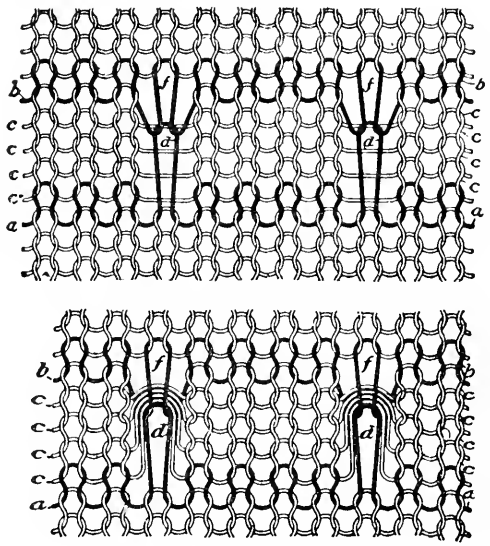


Fig. 170. Interknit Loops for Color Effect.

loops *f f* from thread *b* when drawn down by the knitting-cams, shed simultaneously loops *d d* and the four unknit white threads over their backs, thus interlooping all five threads with the loops *f f*. Thereafter these needles continue to knit, as do their fellows, and plain knitting is produced, until it is desired to again reproduce the pattern, when the operation repeats itself.

If, instead of throwing these needles in at a point *above* the feeding-level, they had been thrown in at a point *below* the feeding-level, the action and resulting fabric would have been the same, except that threads *c c c c* would not have taken within the hooks of these needles, and consequently, instead of being interlooped with loops *f f*, these four threads would pass across straight behind loops *f f* and *b b*. The resulting fabric is shown in the lower illustration. Fig 170.

STOCKINGS WITH OPEN OR LACE WORK

In the accompanying illustration (Fig. 171) is shown a seamless hose or stocking knitted in one continuous operation, upon a circular knitting machine, and having its front ornamented with one or more sections of lace work extending from the upper part of the leg, over the instep and onto the foot. The rear portion of the leg, the entire heel portion, the back or sole portion of the foot, and the entire toe portion, are all made of plain, regularly-knit fabric. The front of the stocking, extending along the leg and over the instep, is formed of sections of plain, regularly-knit fabric interposed between other sections of open or lace work united to the plain sections and knit therewith. In the operation of knitting, the thread, as it leaves the plainly-knitted portion of the stocking, crosses a space of from three to five plain stitches or loops in a crossing-thread or loop, when it is again knitted in the regular manner for a single stitch. Then again it is made to form another crossing-loop or thread; and so on until a lace section is completed. A plain intervening section is then knitted in the usual manner; then another series of open-work spaces; and so on until the entire number of lace and plain sections are completed. This method is followed for three courses, when the thread, instead of being formed into the cross-thread, is midway of its length made to form the long, loose loop in each of the open-work spaces. This operation is carried on throughout the entire portion of the leg, instep, and foot, which it is desired to provide with the lace-work.

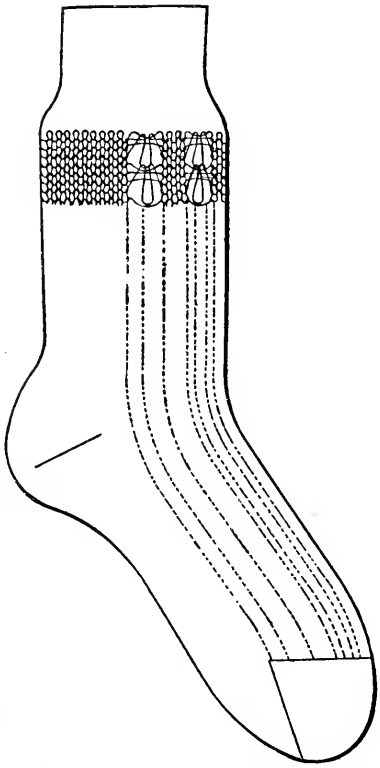


Fig. 171 Seamless Open Mesh Work Stocking.

The entire stocking is thus formed of plain, seamless, knitted, tubular fabric, in which the leg, instep, and foot portions are provided with alternate sections of plain and open or lace work knitted together.

An ordinary plain portion is formed at the back or rear of the leg, and is continued in the heel, the bottom of the foot, and in the toe portions of the stocking.

A stocking having sections of lace work alternating with sections of plain knitting around the entire leg, such as here shown (Fig. 172), may be made as follows:

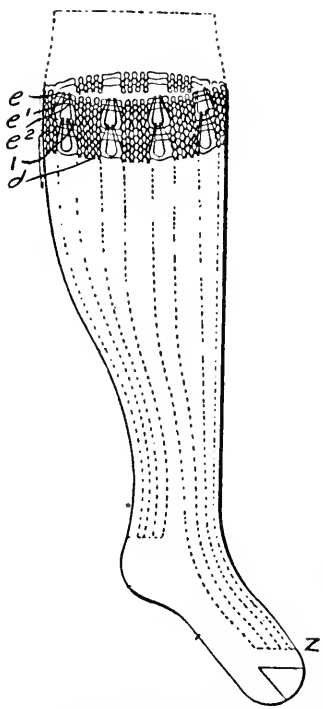


Fig. 172. Making a Lace Work Stocking.

Starting at the plain section, the thread forms a straight cross-thread e to the next plain section, crossing the space of one or more plain loops. A given number of plain loops are then made. The thread then makes a further cross-thread to the next section of plain knitting; and so on entirely around the leg of the stocking. On the next round, the cross-thread e^1 is made in like manner. On the third round, the cross-thread e^2 is made in the same manner. On the fourth round, the cross-thread is drawn down over the three cross-threads $e\ e^1\ e^2$, forming the elongated loop d, as is well understood in the knitting of tuck fabrics. This is continued to the point where the heel is knitted of plain loops. After the formation of the heel the knitting is continued, forming the bottom of plain loops and the top of the ornamental courses and plain sections, until the point z is reached, at which point a number of plain-knitted courses are formed entirely around the stocking. The toe is then completed with plain loops.

This stocking may be made of one continuous thread, or it may be made by knitting the heel and toe of one thread and the remaining portions of the stocking from another thread, or it may be made by

forming the heel and toe of one thread and the other portions of the stocking knitted from two, three, or four other threads, as the operator may prefer. The stocking may be knitted upon a machine constructed in the well-known manner to produce tuck-knitting, provision being made for causing the needles of the front and back portions of the stocking to be thrown separately into operation to knit tuck or plain knitting, as desired.

Another method of ornamenting a stocking upon both front and back, is as follows: The lace-work upon the front is produced in such manner that where a lace-work stripe is to be made, a needle is omitted

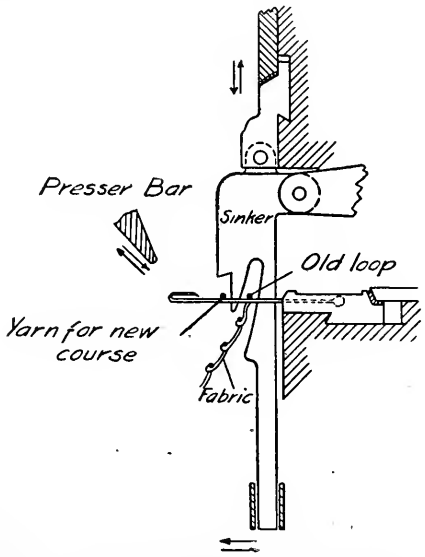


Fig. 173. Position of Loops, Needles, Jack-Sinkers, and Presser Bar Taking the Thread.

from either side of an intermediate needle, which needle is operated to tuck or retain its loops for several courses. Two needles may even be omitted from either side of the intermediate needle. It is apparent that the actual omission of needles from that portion of the machine which forms the back of the leg would prevent the proper formation of the heel and toe pockets, and the sole of the foot.

In producing this effect, the following disposition of needles is made—an omitted needle, a tuck-needle, an omitted needle, a plain needle, an omitted needle, a tuck-needle, and an omitted needle. Here the tuck-needles knit two and tuck two. The ornamentation

down the back of the leg is not so open as the real lace work upon the front of the stocking, and may be described as "imitation lacework." It is produced by two tuck-needles separated by a single plain needle and without any omitted needles.

In forming this stocking, all of these tuck-needles throughout the knitting of the tubular portion of the leg, knit for two courses and then tuck for two courses; and so on in regular alternation, so that the mechanism for specially operating the tuck-needles is in continuous operation during the entire knitting of this portion of the stocking. Upon reaching that point in the operation of the knitting of the stocking when the formation of the heel upon the rear fashioning set begins, the mechanism for specially operating the tuck-needles is thrown entirely out of operation; so that, throughout the process of narrowing and widening, the tuck-needles operate as do all the others, thus producing a heel of ordinary plain knitting. Upon reaching the point of operation at which the formation of the foot begins, the mechanism for specially operating the tuck-needles is in operation during that half of each course of round-and-round knitting which corresponds to the upper half of the instep; but it is out of operation during the remainder of each course. Thus the sole of the foot is knit of plain knitting, all of the tuck-needles that occupy the portion of the needle-cylinder with which this part of the stocking is made being operated as ordinary needles; while, on the other hand, the top of the instep is knit with longitudinal stripes corresponding to the front of the leg. Upon reaching the point of operation at which the knitting of the toe-pocket begins, the tuck mechanism is again thrown altogether out of operation, and the toe-pocket knit, as usual, upon the rear fashioning set, all the needles knitting in the ordinary way.

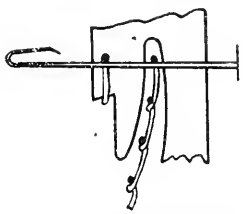


Fig. 174. Sinker Measuring off New Loops.

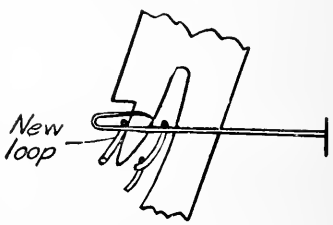


Fig. 175. Sinking into Hooks of Needles.

It is obvious that the limitations which are imposed upon the ornamentation by lace-work of stockings produced upon circular machines by a continuous operation, do not exist in the formation of

stockings upon the straight-bar machine or stocking frame, for in such machine a transfer point may be provided for any needle, and the loops may be transferred to produce the greatest variety of ornamental or lace work.

STRAIGHT HOSIERY FRAMES

In the old, straight machines, the thread, guided by a tubular carrier, was traversed along the needles, after which a row of jack-sinkers, one acting on the thread (see Figs. 173, 174, 175, 176 and 177) in each interstice between the needles, was caused to move down to draw the thread into loops, the last row of loops knit meanwhile hanging from the shanks of the needles behind the new course of thread. The new loops were then carried into the needle-hooks by the motion of the jack-sinkers or of the needle-bar; the old loops were held from moving with the needle, or moved on toward the needle-head, by the jack-sinkers contracting with the previous fabric; while the presser-bar, acting on the needle-barb, closed it so that it passed through the old loop, carrying the new loop with it. Thus the new loop remained on the shank of the needle, and the same cycle of movement was repeated.

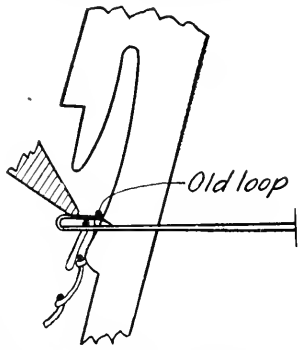


Fig. 176. Barbs Pressed: Sinker Landing Old Loop on Barbs.

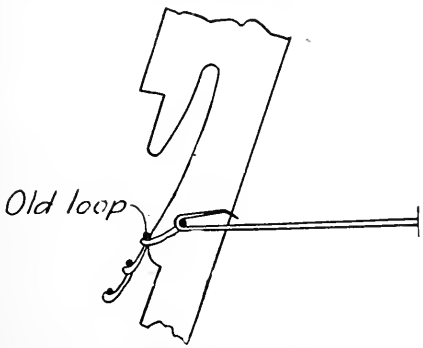


Fig. 177. Presser Bar Retired: Old Loop Knocked Over Head of Needle, Sinker Returns to Position 173.

The old, straight hand frames of William Lee's system were built with a seat which was conveniently placed so that the operator might have free use of both feet as well as both hands, such frames requiring all four to operate. The seat was a part of the framework of of the machine. When the rotary shafts were applied, the seat part of the framework was done away with. The rotary crank-shaft was connected by means of wheels or belts with the main shaft, on which were

cams and levers connected to the slur-cocks, sinkers, pressers, etc., whereby they were actuated in the proper time and order to perform their functions. This rotary shaft had its bearings so located that it was in convenient position for the operator to turn as he stood in front of the frame, the shaft being made with two (sometimes more) cranks, similar to the rotary crank-shaft of the present flat-rib machine. When the change was made, they were called *rotary* frames, probably to distinguish them from the old *hand* frames; possibly the hand frames were simply called *knitting* frames up to that time. After development of the rotary shaft frame, it seems but an easy step to extend the shaft and secure a pulley on it to be driven by a belt transmitting horse- or water-power. This straight rotary spring needle frame has been improved upon at different periods, by various parties, until what is known to-day (1906) as "Cotton's" system has developed.

The first circular machine on record seems to have been the one described in the British patent in 1816 granted to the celebrated engineer, Mark Brunel, which invention he obtained from some unknown source in France. In this machine the needles were placed radially on a circular plate, with mechanism to feed the thread arranged to rotate about the circle. This arrangement made a continuous seamless tube of fabric at a greatly increased speed. This was the first *circular* machine. The spring needles were soon placed in a belt around an open cylinder, in a more convenient arrangement.

Thus the term *circular* has been used to designate this type of machine whether the needles were spring or latch, radiating inward or outward or both, or whether they were positioned vertically, with needle cylinder or cam cylinder revolving with or without dial needles. So, too, has the term *rotary* been used to designate that type of straight machine which includes rotary shafts. The term *frame* or *machine* is, to-day, simply a matter of choice, in either case.

THE "COTTON" TYPE

Fine hosiery—that is, fine in the smallness of mesh and of yarn and in perfection of shaping of the flat blanks—is knit almost exclusively upon flat-bed machines of the "Cotton" type.

These machines are fully automatic in their operation, a single controlling and pattern mechanism serving to operate simultaneously as many as twenty-four like knitting-beds, each of which makes the

shaped web for a stocking. The needle-beds move in these machines in a path having two dimensions; the presser-bar may be fixed, and the sinkers have only a vertical motion. This is ingeniously given by a cam traversing with the thread-guide and a lever attached to or integral with the sinker, which so multiplies the slope of the "wave" of depressed sinkers as to carry each one to the limit of its motion before its neighbor has started to move, avoiding abrasion and strain on the yarn.

The motions of the machine for knitting, and while transferring the group of end stitches, are very different; they are controlled respectively by two distinct sets of cams on the main shaft of the machine, which shaft is moved endwise at the proper time to accomplish the change.

Fashioning, narrowing and widening the knit web is done on these machines by transferring the loops from several of the edge needles in use on to a separate instrument, moving them one or two needle-spaces in or out, and then replacing these loops on the needles.

In knitting a so-called "full-fashioned" stocking it is customary to commence the knitting at the widest portion of the leg, the knitting being performed on flat machines having spring-beard needles, and the strip being knitted of a uniform width until the calf portion is reached, whereupon the strip is narrowed by the transferring of stitches from the end needles on both sides of the machine toward the center of the fabric, until the fabric has been sufficiently narrowed for the ankle portion of the stocking, the latter being then knitted of uniform width until the formation of the heel is necessary.

At this juncture two yarn-guides are thrown into action, one employed for knitting a projecting heel-piece at one side of the ankle-web, and the other for knitting a corresponding heel-piece at the opposite side of the ankle web, the intervening needles of the machine having the stitches cast from them. The heel-strips are knitted of uniform width down to the point where the rounding of the heel is to be effected, whereupon each of the strips is narrowed to the desired extent by transferring stitches from needle to needle in the same manner as when narrowing for the calf portion of the stocking.

When the knitting of the heel-strips has been completed, they are cast from the needles; and the selvaged inner edges of the heel-strips are run upon the outermost needles of a separate machine known as

a *footing machine*, the intermediate needles of this machine receiving the loops around the instep portion of the leg-web which were thrown from the needles of the leg-machine when the formation of the heel-strips was begun.

The foot-web is then knitted upon the needles of the second

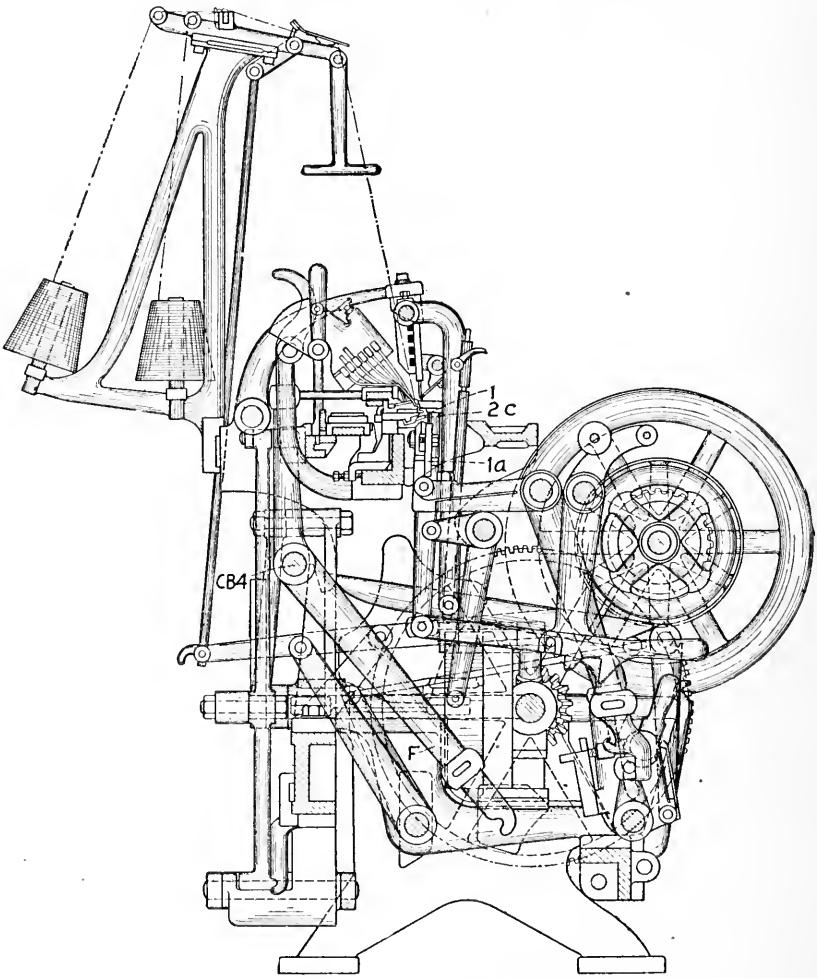
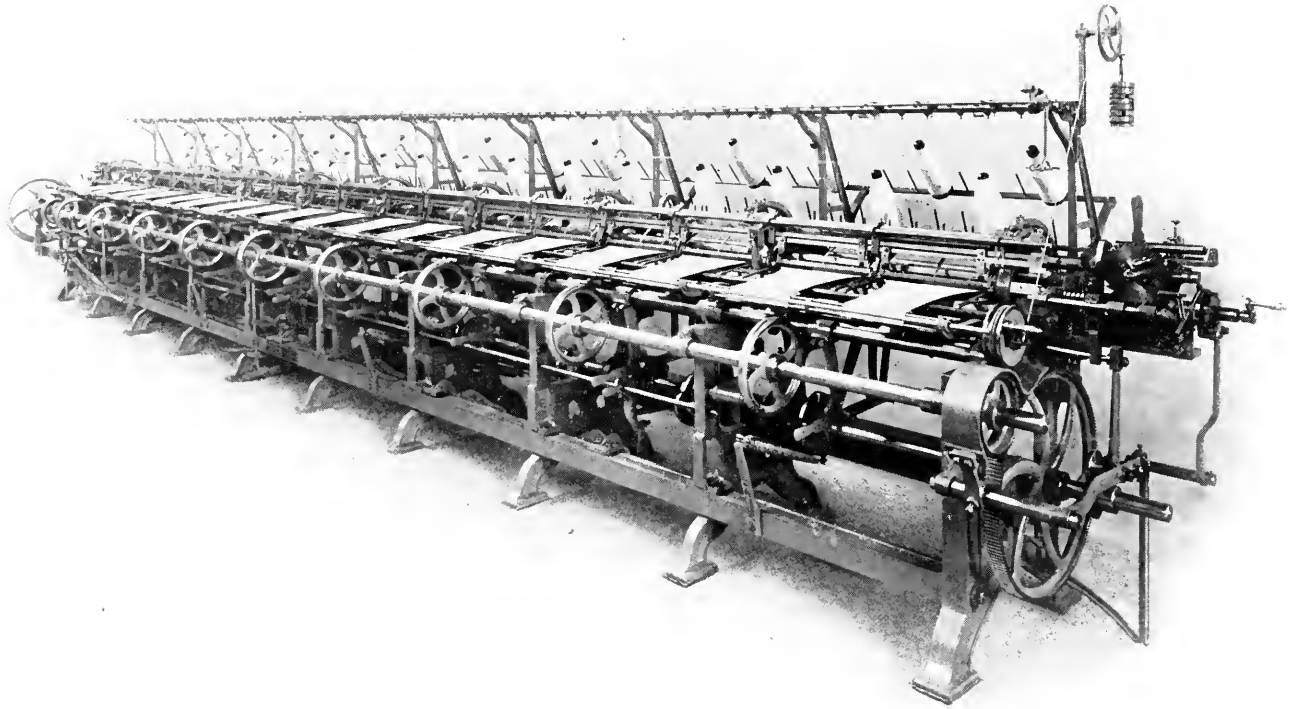


Fig. 178. Diagrammatic View of Textile Machine Work's Footer.

machine, the web being narrowed at each side to form the desired instep-gussets, and being also narrowed at the toe, so as to properly round the same.



FULL FASHIONED HOSIERY KNITTING MACHINE OF 18 SECTIONS, WITH SPRING BEARD NEEDLES—BUILT ON COTTON SYSTEM

Otto Walther

This method of manufacture necessitates sewing or seaming operations to complete the stocking, because, as the stocking-blank is knitted in the form of a flat web, it is necessary to unite the edges of this web by a seam extending down the back of the leg, calf, ankle, and heel, and by another seam extending under the bottom of the toe, foot, and heel.

Generally speaking, the advantages of a full-fashioned stocking over the product of a circular machine, consist in the fact that the former is shaped or "fashioned" in such a way that the fabric is narrowed by the dropping of stitches to suit the contours of the leg and foot, and to insure a perfectly fitting stocking. Another advantage of a full-fashioned stocking is that it is made with spring needles, which leave the yarn its full amount of elasticity, as it is subjected to very little strain during the operation of knitting. This results in a fabric of great elasticity, such as is not produced on a seamless machine using latch-needles, even though the same number of needles per inch be employed.

In addition to these points of superiority of the full-fashioned stockings resulting from the method of making, the construction of the machine and the accessibility of the co-operating elements permit of producing effects of design or ornamentation which it is impossible to produce by circular knitting.

The underlying principles of machines of this system are pointed out in detail with reference to the illustrations of the machine built by the Textile Machine Works at Reading, Pa. The formation of the loops is produced in the following manner:

The needles shown at 1 (Figs. 178 and 179) are clamped in the needle bars shown at 1A, and stand in a vertical position. Instead of the former method of casting needles into leads, they are securely held in position by slots being milled in brass bars and holes drilled through these bars, whereby the end of the needle shank is held, this end being bent at right angles to the length of the needle. These brass bars are securely fastened against steel needle-bars. The steel needle-bars form independent sections, generally of a length to make two stockings. Clamping plates three inches in length are used to hold these needles securely in place; and in the latest construction these plates are so arranged that they can be loosened by unscrewing a bolt from the front of the machine whenever it becomes necessary

to replace a broken needle. This is found to be a great convenience, as the replacing of a needle can be done very quickly.

The loops are formed by sinkers, of which there are as many as there are needles. Each sinker is placed in the center between two needles. Two kinds of sinkers are used, termed *jack-sinkers* and *dividers*. The jack-sinker is reinforced at the rectangular rear end by steel plates, to provide a better and more durable surface for the "jacks" to strike against. There is always one jack-sinker alternating with a divider. The jack-sinkers form a loop over every two needles and the dividers divide the same, to give an equal loop to each needle. Sinkers and dividers have projections at their front end, which are termed, *nib* and *nose*. The nib is used for forming the loop, while the nose separates the new loop from the old one during its formation and until it has been drawn through the old loop.

The sinkers have an independent motion, which is given them by the jacks, of which there is one to each sinker. The dividers are moved forward by the catch-bar, which is so shaped as to control also the backward movement of the sinkers. The catch-bar extends across the whole width of the machine, and is supported by the catch-bar arms, which, at their opposite ends, are connected to other arms attached to the rocking shaft C B4 (Fig. 178), which shaft receives its rocking motion by levers F extending to the main shaft and carrying a roller at their lower end, which is acted upon by the catch-bar cam.

The movements of these various parts to form a row or course of knitted loops, are as follows: The needles stand with their beards above the tops of the sinkers, while the nose of sinkers and divider protrude between them. The thread-carrier lays a thread in front of the nib of the sinker, and behind the needle shanks. The sinkers, having an individual movement, as explained, are each brought forward, one after the other, by the jacks, which are pressed against the back of them by the "slur-cock" as it travels across each division of needles. By this movement, each sinker forms a loop between alternate needles. When these are completed, the dividers are brought forward all together by means of the catch-bar to form a loop between those needles that had no loops formed for them by the sinkers. In order to provide thread for the dividers, the needles all move back nearer the sinker-nib, freeing part of these loops to be taken by the dividers, and so forming a series of loops around each needle-shank,

all of which should be of uniform size. The needles then descend to such a distance that the new loop passes under the needle-beards; and the needles are moved toward a fixed presser-bar to close the beards; so that, as the needle-bar descends still farther, the point of each beard shall enter the old loops, being landed on top of the needle-beards, and, finally, in a further descent of the needles, being knocked over the head of the needles by the knocking-over bits, the sinkers and dividers in the meantime retiring to give a free passage to the old loop

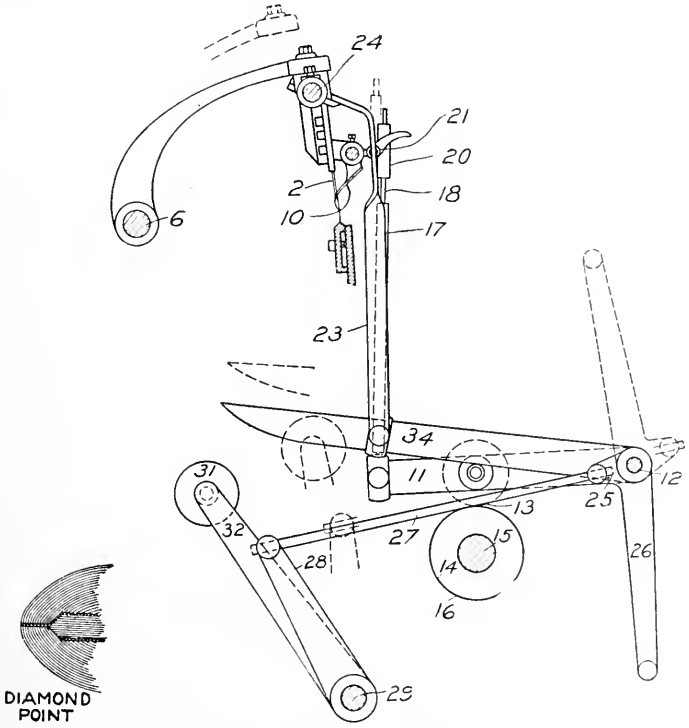


Fig. 179. Narrowing Mechanism, Raising Device, and "Diamond Point" Mechanism

as it goes over the new one. The whole row of old loops being over, the needles commence to rise, the sinkers and dividers coming forward above the loops to hold them down in position, ready for the making of the next row of new loops, which are commenced as soon as the needles have reached their normal position again.

Fig. 178 shows a diagrammatic sectional view of a *Footer*; and while it shows plainly the well-designed, mechanical construction

and the strong proportions of the machine, some of the new details of improved construction are shown in the other illustrations.

Fig. 179 illustrates a very convenient improvement for raising the narrowing mechanism; also an improved mechanism for producing the *diamond point* at the toe of the foot of a full-fashioned stocking.

The raising and lowering of the whole narrowing mechanism is conveniently effected, and the narrowing machine is rigidly held in the raised position by employing a lever 34, fixed to the shaft 12, and pivotally connected to a rod 23, which in turn is pivotally attached at its upper end to the shaft 24 of the narrowing mechanism, in con-

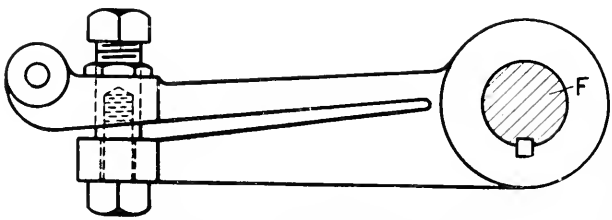


Fig. 180. Needle Bar Micrometer Adjustment.

nection with a hand mechanism for operating lever 21, comprising a bell-crank 25, 26, loosely mounted on the shaft 12, and having its short arm connected by a pivoted rod 27 to an arm 28 on shaft 29. The turning of the latter by the swinging of the bell-crank arm 26 upward to its dotted position against the stop 30, causes the end 31 of arm 32 on shaft 29 to swing forward to its dotted position indicated, thereby raising and holding rigidly in place the entire narrowing machine.

This is very convenient for straightening the needles or putting new ones in the machine in place of broken ones. In order to produce the "diamond-points," the guard-blades 10 are employed, which are swung toward the fashioning points 2, and press against some of these points, preventing them from engaging with the corresponding needles and the picking of the loops from such needles in the operation of *footing*. The movement of the guards 10 into and out of contact position with the fashioning points 2, is effected automatically during the operation of the machine by means of levers 11 and connected mechanism as follows:

The lever 11 is pivoted at one end to a shaft 12, and is provided

intermediate of its length with a roller 13, which bears normally upon the concentric periphery 14 of a disc fixed to the rotary shaft 15, upon which the lever is thus supported without movement; but when the shaft 15 is moved longitudinally during the narrowing operation, the bearing of roller 13 is transferred from the concentric disc to an eccentric periphery 16, which raises the pivoted lever 11. Pivotally con-

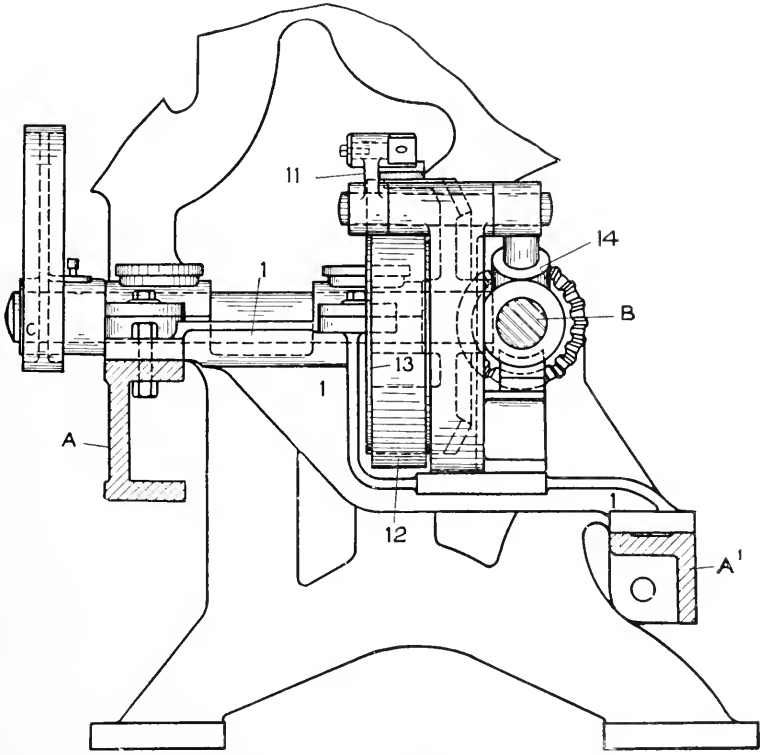


Fig. 181 Draw-Cam Shaft, Bearing, and Brake

nected to the free end of the lever 11, is a rod 17, the upper end 18 of which is engaged so as to slide in a sleeve 20, which in turn is pivotally connected at 21 to an arm 22 fixed to the shaft 8. The free movement of the rod-end 18 in said sleeve is limited by a shoulder or stop 19, which comes in contact with said sleeve before the lever 11 is fully raised, and raises it, so as to turn the shaft 6 and swing the guards 10 outward, as indicated by the dotted lines.

Fig. 180 illustrates a very important improvement, which allows

of a micrometer adjustment of the needle-bars. It is very important that the needles should always be in exact co-operating position with the sinkers; and it will readily be understood by referring to the illustration, that the double bolt and jam-nut of this double-armed needle-bar crank furnish accurate means for doing this.

Figs. 181 and 182 show an improved bearing for the draw-cam shaft, and an improved brake for arresting the movement of the draw-cam shaft as soon as the longitudinal movement of the main cam-

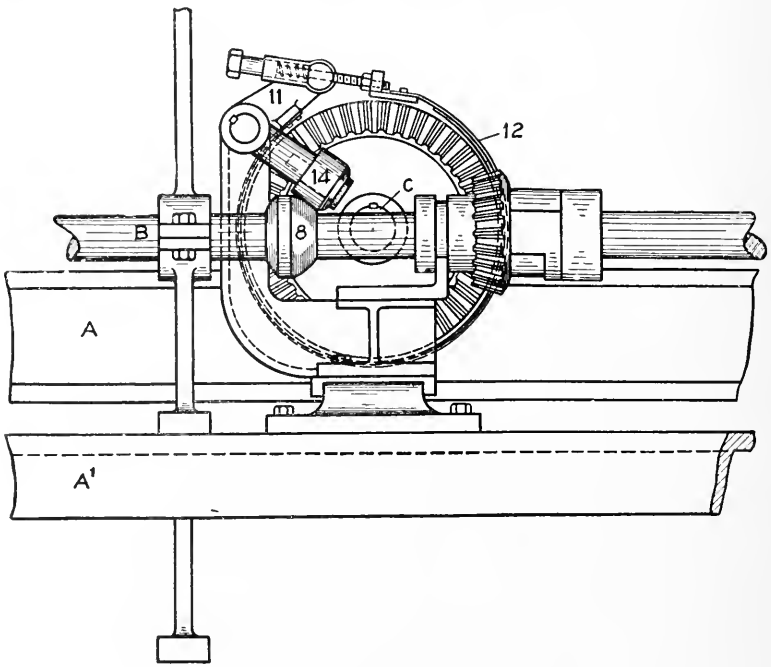


Fig. 182. Draw-Cam Shaft Brake.

shaft takes place—in other words, as soon as the machine commences to narrow. In nearly all other machines this stopping of the draw-cam shaft is done by a key pushing in between the teeth of the bevel gear on the cam-shaft. This improved brake works with a steel band, leather lined, adjustably secured, and tightens as soon as shaft B is longitudinally moved (see 8, 14, 11, 12, and 13). The construction of bearing 1 not only forms a substantial one-piece bearing for the draw-cam, but at the same time bridges and braces transversely the entire machine, by being bolted to beam A in the rear and beam A¹ in the front part of the machine.

LACE EFFECTS AND OPEN MESH WORK

The high perfection of the Cotton type of flat-bed knitting machine, has enabled these machines to compete successfully in the manufacture of ornamental high-grade open-work products—stockings, of course, being the chief output in this line. Such machines can be used very successfully for producing fabrics of great variety in design, with any perforated patterning that may be desired, and without changing anything in the machine that would prevent its being easily restored to the making of hosiery. The slowness of operation in these machines is more than compensated for by their ability to turn out simultaneously a number of fashioned blanks suitable for the finest grades of underwear, while at the same time making any pattern of open-mesh work in the fabric that can be formed of tuck-work, transferred stitches, or dropped stitches. The following is a detailed description of such a machine equipped for the production of open-mesh fabric wherein loops are transferred from one needle to the adjacent one by a transfer point (see Fig. 183). Of course the pattern shown in Diagram H may have the open spaces X at much more frequent intervals.

The lace-needles are represented at 1, the stop-needles at 2, and the knitting-needles at 3. The needles 3 are provided in larger numbers than the others, and form a connected row, while the lace-needles 1 and the stop-needles 2 are comparatively few in number, and stand in smaller groups of two or three, according to the nature of the open-work pattern to be produced. The lace-needles 1 are secured in the lace-point bar 4, while the knitting-needles 3 are secured in the needle-bar 15. The lace-point bar 4 is suspended from the shaft 17 through the medium of the arm 16; and these parts 1, 4, 16, and 17 may be called the *open-work attachment.*

The narrowing-needles 6 are secured in the smaller needle-bars 7 and 8. All the needle-bars 7 are rigidly connected to the bar 9, and all needle-bars 8 to the bar 10. These enumerated parts 6, 7, 8, 9, and 10 are mounted upon the shaft 11, through the medium of the lever 5, and may be designated as the *fashioning* or *narrowing attachment.* The sinkers 12 in their operation are moved to and fro horizontally. The knocking-over bits 18 remain fixedly in their place.

Diagram B shows the positions of the parts at the moment when the knitting-needles 3 have reached the highest point in their move-

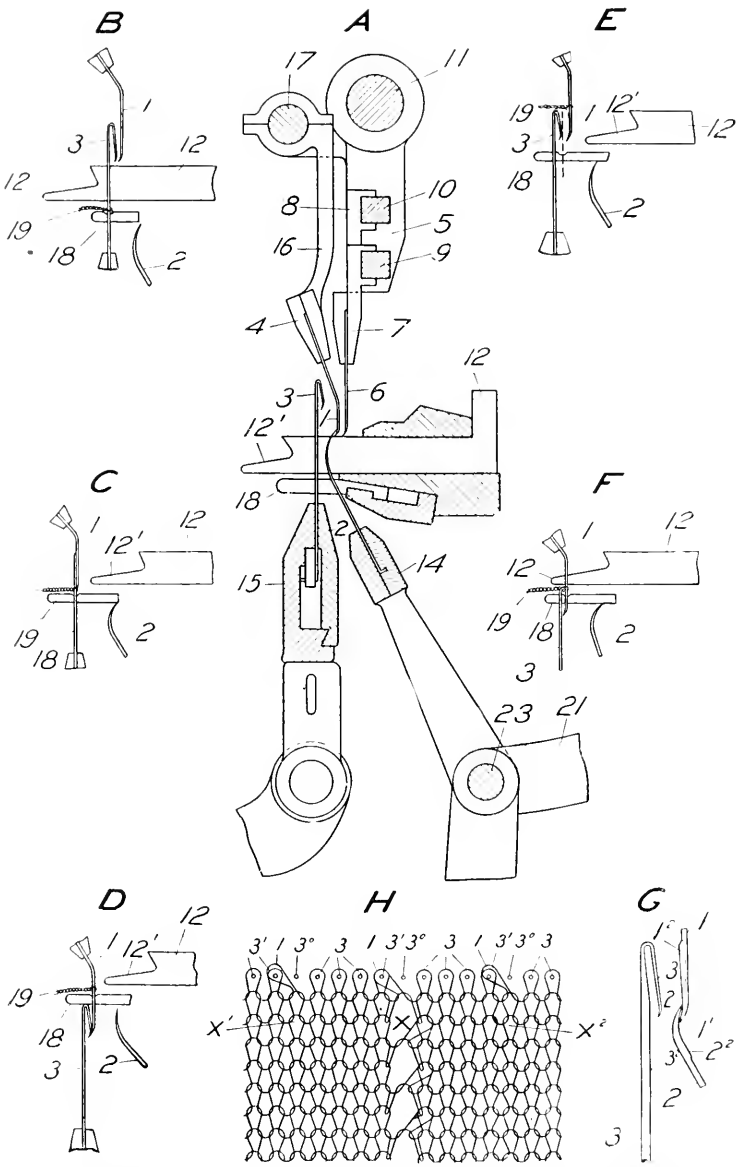


Fig. 183. Transferring Loops, by Transfer Point, to Produce Open-Mesh Fabric.

ment, the web 19 hanging on the knitting-needles, the sinkers 12 being projected, and the lace-needles 1 being about to lay their grooves upon the knitting-needles. In Diagram C the lace-needles have so laid themselves upon the knitting-needles 3 that their points 1^1 have entered the grooves 3^1 (Diagram G), and the beard 3^1 is entirely covered by the groove 1^2 (Diagram G). Thus tightly closed together, the two needles move downward through the loops. The loops resting upon the jack 18 are stripped from the knitting-needles 3 and shoved upon the lace-needles 1. This series of steps in the formation of the loops takes place only where the lace-needles 1 are located in the lace-point bar 4. Those knitting-needles 3 which are not covered by lace-needles 1, retain their loops and produce a smooth web.

Diagram D shows the next succeeding moment of the needle operation. Web 19 no longer hangs upon the knitting-needles 3, but has now been fully pushed upon the lace-needles 1. The lace-needles 1 now begin to elevate themselves from the knitting-needles 3. In Diagram E both needles 1 and 3 have moved upward; the web 19 has been carried upward with them; and while this was taking place, the lace-needle 1 has with them raised itself from the knitting-needle. In this elevated position of the needles, the shaft 17, together with all the parts mounted upon it—being one or two needles, according to the pattern of the goods—is moved to the left or right. Upon shaft 17 is secured the lace-point bar 4, and the needles 1. Since upon each lace-needle 1 a loop hangs (Diagram E), these loops will be taken laterally a distance of one or two needles; and at this point the knitting-needles 3 (Diagram E), move into the dotted position, so that the loop can be transferred from the needles 1 to the needles 3. This may be clearly seen in Diagram H, where a number of knitting-needles 3 are shown from above in horizontal section. The knitting-needles 3 are hung with loops, excepting the needles 3^0, which are cleared in consequence of the lace-needles 1 having taken the loops from them and covered them by the neighboring needles 3^1, as illustrated in Diagram E.

In Diagram F both of the needles 1 and 3 now move again downward. The web 19, which was elevated in Diagram E, has been taken downwardly in Diagram F, and again rests in the position which it assumed in Diagrams B. C, and D upon the knocking-over bits 18. The sinkers 12 now move forward horizontally and secure the web 19

so that it is confined between the knocking-over bits 18 and the beaks 12^1 of the sinkers. If now the needles 1 and 3, covered the one by the

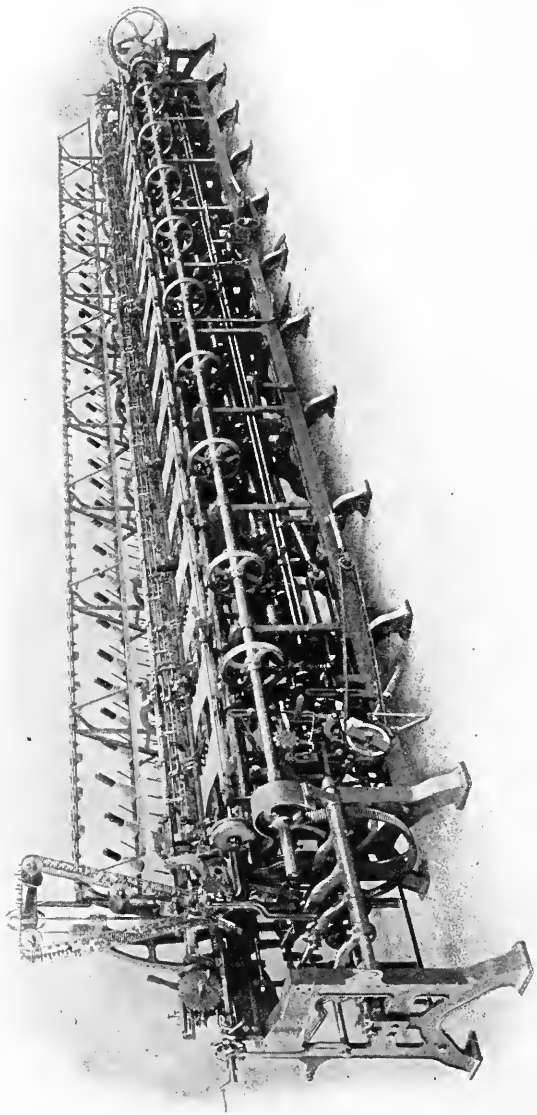


Fig. 184. Schubert and Salzer Full-Fashioned Hosiery Machine.

other, move upward in common, the loops are pushed from the needles 1, and slide among the needles 3 again. The lace-needles 1 are now

free, and again separated from the knitting-needles 3 The parts have now again reached a position similar to that shown in Diagram B.

By the proceedings as outlined with reference to Diagram B to F, beautiful open-work patterns may be produced. Diagram H is not given as a sample of a very artistic production; it is designed simply to show how a progressive series of openings x may be produced. If the three lace-needles 1 in Diagram H are brought into operation, there would be produced not simply the single row of openings x in the middle of the web, but two lateral rows of openings x^1 and x^2. The ornamentation of the pattern and the variegation thereof can be accomplished to a very much greater extent by interrupting one or more of the lace-needles 1 for the production of openings x at will. It is also practicable to omit openings and introduce plain work, just as often as may be desired, along the lines x^1 and x^2. If in Diagram H it should be desired to introduce a row of openings at 3° 3° 3°, this can likewise be accomplished by simply omitting all of lace-needles 1 1 1.

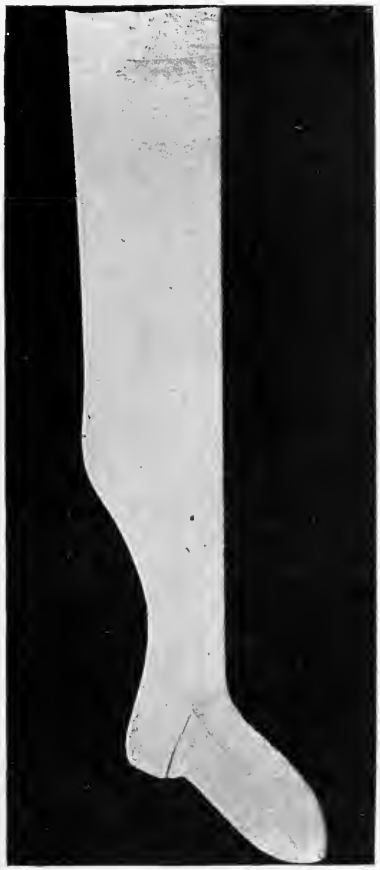


Fig. 185. Ladies' Full-Fashioned Stocking.

Fig. 185 shows a ladies' full-fashioned stocking of mercerized thread made on a 39 gg. (gauge) or 26 needles to the inch Schubert & Salzer machine. It has spliced garter top, heel, sole, and toe, and is narrowed in the leg, heel, instep, and toe.

SECTION OF FINISHING ROOM WHERE 12,000 GARMENTS ARE FINISHED DAILY

Utica Knitting Company

KNIT GOODS FINISHING AND FINISHING MACHINES

One of the marked characteristics of the time is the increased demand for ready-made garments. The first demand for this grade of clothing seems to have been by sailors fitting out in New Bedford for long whaling voyages. So many men going out of port at one season of the year influenced an enterprising store-keeper to have a lot of clothing made up ready for the rush. This was before the sewing machine was invented; and the clothing, though far from stylish, was comfortable and durable.

From this small beginning came the enormous clothing industry of today, with its many branches, including men's clothing, ladies' clothing, muslin underwear, children's dresses, skirts, shirtwaists, infant wear, knitted underwear, etc. Before the sewing machine came into use, the clothing industry was being rapidly developed, and this undoubtedly served, in a large degree, to spur on the inventors to produce a sewing machine.

The growth of the industry has been marvelous. It is, and always has been, a great incentive to the sewing machine manufacturers to exert their inventive faculties, and in this large special field, a profitable market is found. Large and profitable concerns have been developed in the ready-made garment industry because the manufacture of garments in large lots makes it possible to offer them at prices that command attention and in better style than those turned out by the average tailor or seamstress.

The knitted underwear branch of the clothing industry early saw the advantage of concentrating its help under one roof and under the skill and guidance of experts, and they, quicker than any other branch, also saw the great advantages of special machines. As a result they have today the best equipped factories in the ready-made garment business. Almost every operation, in fact every operation, has a special machine designed and adapted to perform that part of the work. It is an unusual thing for an operator to make a gar-

ment complete in a knitted underwear factory. After leaving the cutter in bundles of one dozen each, they pass successively through different operators' hands for almost every operation.

KNIT GOODS FINISHING

Since the manufacturer of knit goods has undertaken to promote his sales by direct personal solicitation, the details of finishing have become almost innumerable. When knit goods were marketed chiefly by the commission houses it was customary to sell the goods as the sample was made up, but when the manufacturer, to close his sales, sought to do a little better than his competitor and offered to "cat-stitch", to put on Prussian binding, or four buttons instead of three, or pearl buttons instead of bar, or a ribtail instead of hem, or collarette instead of binding, or stitched with silk, or one quality of golloons here, and another quality of buttons—cloth, bar, ivory, bone, shell or pearl—single stitched, two needle stitched, or three rows of stitches, or some of the innumerable catch features adaptable to the finishing of underwear, he built up for himself and for the entire trade an interminable number of styles to perplex himself as well as his help and retard production; because this or that lot must be marked 88AB21 or Xo 225, or with some other hieroglyphic equally difficult to keep run of, and sort out.

We will take under consideration the more important processes, leaving the more stylish designs to be acquired after due experience.

Between the first attempts to produce factory-made underwear and the many fine examples of the art before us on every hand at the present day, is a goodly journey, and to one who has been a privileged observer of even a part of the necessary changes, both mechanical and artistic, which have followed one after another during this period, the transformation is of vast interest.

From an artistic standpoint, and in a peculiar sense, much of the credit for the excellence of our present-day underwear must be given to the garment designer. This person is never satisfied with a new design or effect if another suggests itself which seems better; and if mechanical difficulties prohibit its adoption, they are but a spur or incentive for the inventor, and are looked upon as things to be overcome. The cares and designs of the garment maker, or originator, however, are of a different nature from the foregoing,

in that there is never any surety that the particular style of finish or cut of a garment, which is finally worked out with such exceeding care, will remain in vogue longer than one season at the most.

Fabric. These most useful and necessary garments are today made in an almost inconceivable number of styles, and in as many different qualities. There also seems to be no end to the different kinds of fiber which may be used one way or another in their fabrication. Silk, wool, cotton, ramie, mohair, camel hair, flax, etc., are all adaptable in some form or other, or in various combinations, so that we are able to select garments that are not only perfectly adapted to meet our requirements of warmth for the winter season, or cool comfort in the warmer months, but every grade shows remarkable taste as to finish and texture of the fabric itself.

Yarn. In making the yarn for this peculiar elastic fabric, we have recourse to all of the various fibers which are used in woven fabrics, but differing from the latter, a knitting yarn must be smoother and more even. If these requirements are complied with, the knitting process is much faster than weaving, and consequently a greater quantity of knitted cloth can be made at the same cost, than of a woven fabric of equal quality. For this reason, and because of the elastic nature of a knitted fabric, it is especially suited for wear next to the body, and has taken the place of all other kinds of material for this purpose.

The finest results are obtained by the use of silk yarn, yet many very satisfactory fabrics are made from lisle thread and mercerized cotton; fibers that are much cheaper than silk. Such fabrics retain their style, shape and brilliancy through much hard usage, and many trips through laundries. Indeed, the problem seems to be that on the medium-priced garments the trimmings, which are necessary to present a sufficiently neat appearance, must be of a somewhat better quality than the fabric itself, in order to wear as well.

Making Up Samples. In making up samples for an approaching season, the designer's field would appear to be somewhat limited, from the fact that the general styles or character of these garments have now become standardized, and are in a measure arbitrary. Thus the vest or shirt of a two-piece suit will allow of but little alteration from the usual shape, except in the length of sleeves or cut of the neck; and with the pants and drawers which complete these

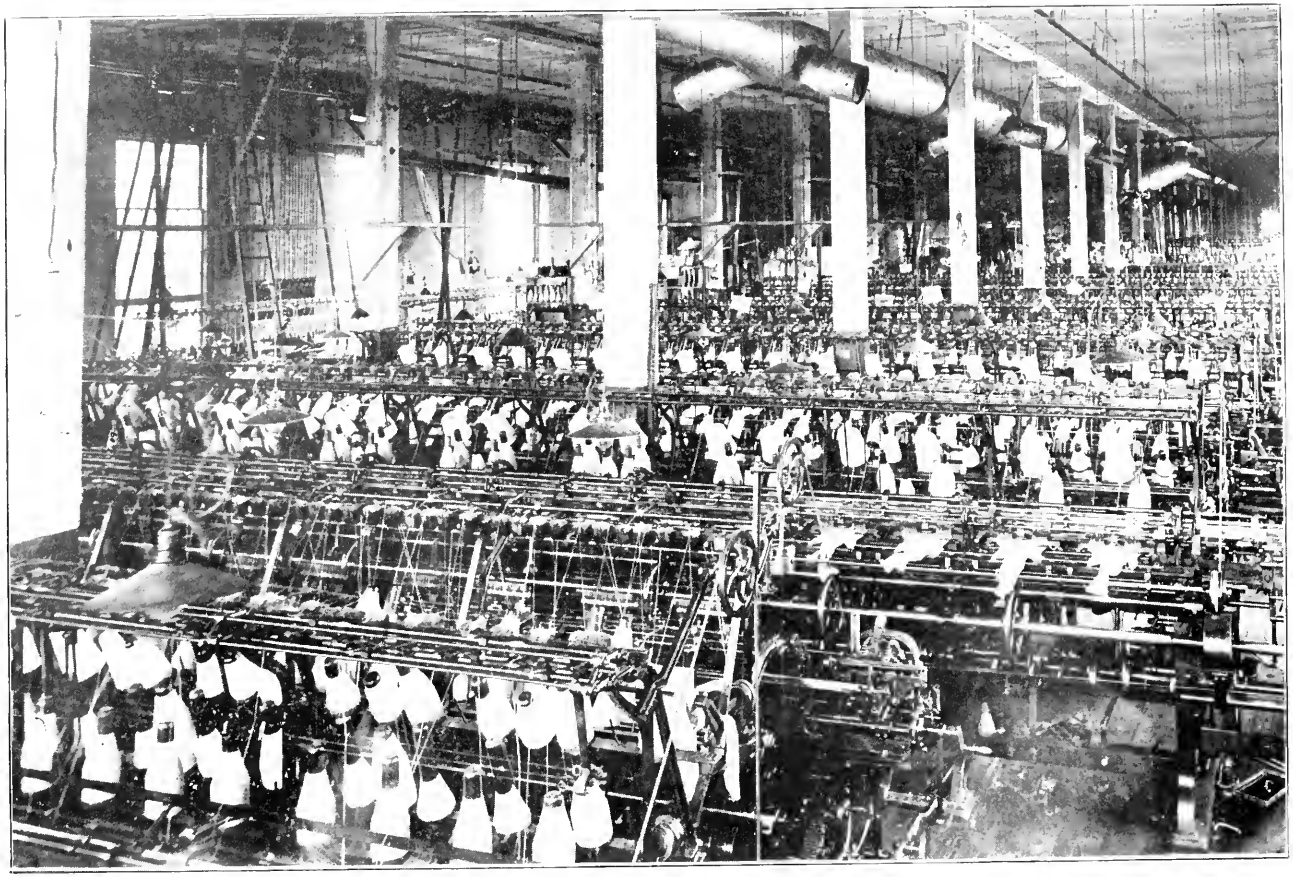
suits there is still less opportunity for change. In the case of one-piece or union suits, which are integral from neck to ankle, these restrictions also exist and are, if anything, more arbitrary than with the two-piece styles.

Under such conditions it is evident that any very radical innovation in the cut or shape of these garments is out of the question; so the designer's efforts must of necessity be confined to the minor details of texture, finish, color, etc. In this field, however, his art has the fullest scope, for there is no end to the variety of effects that are possible by the use of the various trimming materials, by themselves or in combination; or when introduced as contrasts with the fabric itself; and it is principally these essential details that have brought about the present advanced state of the art. The chief fundamental that must be recognized is that the wearers of these garments demand something that shall be of an even thickness throughout, so whatever may be superimposed in the way of bands, facings, etc., must not be of any appreciable thickness that will cause the garment to appear bulky in any part.

The basic fabric, having been previously determined as to weight, firmness, etc., is sufficient of itself for the requirements of the season, and any extra thickness beyond this often proves uncomfortable to the wearer.

The seams that are introduced to unite the several parts into a garment must also be flat as well as strong, and without any unnecessary ridge or corded appearance. These are prime essentials, which may be considered as standardized, and having provided for them in a satisfactory manner the final detail of finish may be considered. A certain amount of this, is, of course, indespensable, as it is required for the practical purposes of fastenings in the form of buttons, lacings, etc., and as bindings, facings, hems, etc., for protection of the several openings and extremities of the garments. In selecting the materials for these purposes, however, many pleasing effects are possible, and they may be made to serve in a decorative sense as well as being utilitarian.

Selection of Materials. In selecting the nature and quality of fiber or material from which the fabric will be made, it is necessary that the detail of color should be considered in conjunction, because if a specific hue or shade has been predetermined, and a dye or other



VIEW IN ONE OF THE KNITTING ROOMS AT THE WAYNE KNITTING MILLS, SHOWING 18-SECTION FOOTER AT WORK ON HALF HOSE

artificial agent is necessary to produce the desired result, the especial fiber known as the most favorable vehicle must be chosen; for among the many generic dyeing agents, or their mordants, some are more perfectly adapted to a specific fiber than others. If a natural color is desired, that fiber which has the cleanest appearance when in this state must be selected.

Having determined the fiber, color, and gauge of the fabric, and having a finished piece of cloth before him, the designer's task is to shape the pattern or cut of the garment, and to decide on an amount and quality of finish or trimming that seems necessary and appropriate. This is essentially the chief's province, in which there is recourse to no assistance excepting that rendered by the makers of whatever finishing material he needs, such as facing, bands, binding, lace, buttons, etc.

Style of the Garment. The style of underwear in most general use is the two-piece suit, consisting of shirt and drawers, or vest and pants. The one-piece or union suit, however, is fast coming into vogue, and it has several points of superiority that appeal to a large class of users. While there is no intention to establish a comparison, one, and probably the principal, advantage of the union suit may be mentioned.

This is the absence of a double thickness of fabric around the lower part of the body and hips, for, as the garment is of one integral piece from neck to ankle, it adds but a single thickness over any part of the body.

Style of Finish. In selecting an appropriate amount of finish for all styles of these garments, a great deal of care and taste is required, for if too much finish is imposed, or if it be gaudy, the desired effect is at once destroyed; this being especially true of the more expensive grades. In the detail of neck finish, for instance, while a novel effect is always sought for, either by the aid of lace, binding or a piece of the fabric itself having been knit with contrasting stitches, any material that produces a poor effect is at once seen to be out of place. This is also true of the front facing of shirts, and bands on drawers.

The buttons also are made in an endless variety, some being very beautiful, and they assist very materially in producing a dressy effect.

As regards the color scheme of the garment, there are probably as many varying theories on this subject as there are wearers of the garments. So the problem is to exhibit only that which will not offend. An effect that is pleasing has trimmings of a slightly dissimilar shade from the basic color of the integral garment itself. Many times the very simplicity of a design serves to attract attention

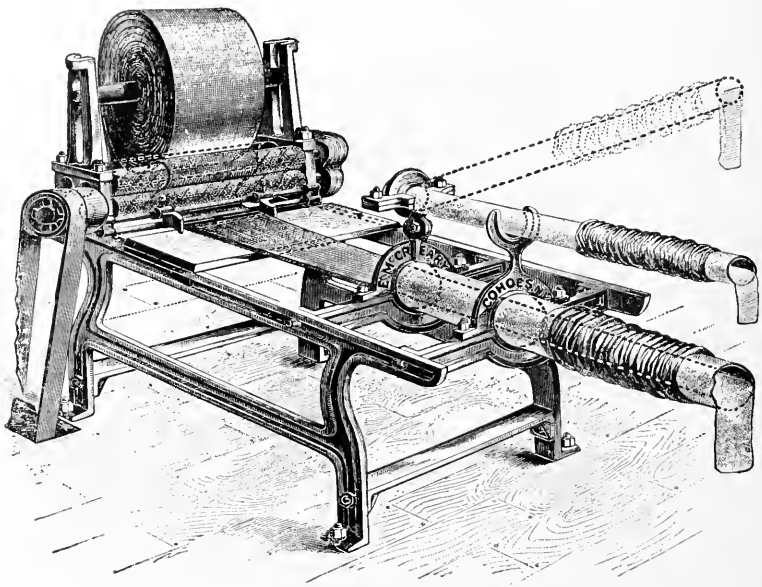


Fig. 1. Turning and Winding-up Machine.

to a fabric that otherwise would fail of notice, even if the greatest skill had been devoted to its every process of manufacture.

FINISHING FLAT GOODS

The manner of handling knit goods, and the various operations required in the process of finishing, is about the same in all kinds of goods, either shirts or drawers, but for convenience a dozen shirts, followed through the mill, will illustrate the successive processes they undergo. The system of tracing the garments with the Stetson coupon check is perhaps regarded as the best and most reliable system for that purpose.

Turning the Cloth. When the rolls of cloth are removed from the take-up, the right side of the cloth is inside the roll; that is, the

inside of the circular web of cloth as it leaves the needles on the frame presents a more sightly appearance, showing as it does the wale or ribs formed by the stitch, while the outside of the fabric presents the annular courses formed in the knitting operation. The beauty of the stitch formed on the ribbed side of the cloth distinguishes it as the right side or face. This requires the web to be turned inside

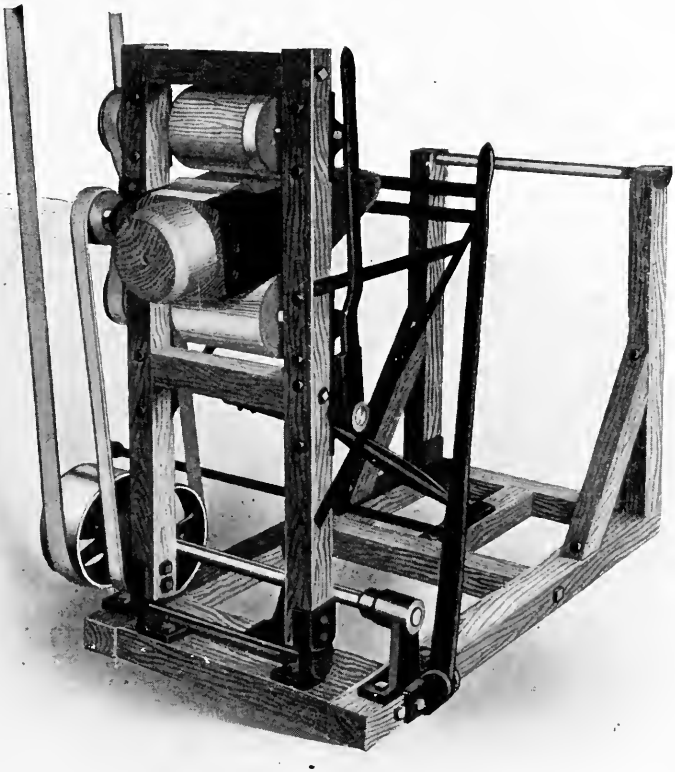


Fig. 2. Leighton Machine Co's. Knit Web Turning Machine.

out, and it is usually most practical to turn it before it leaves the knitting room. The accompanying cut shows very clearly the mode of accomplishing this operation by machinery. (See Fig. 1.)

The web of cloth is drawn on the tube or cylinder until the other end can be introduced into and drawn through the inside, and started around the roll at the further end of the machine, and

the power applied and the cloth rolled up in shape to be delivered to the cutter. The machine is simple and readily comprehended by reference to the illustration.

The Leighton Machine Co.'s knit web turning machine is an important improvement in the process of turning the web. It is intended to be set up at the end of the turning tubes now in use in knitting mills and to put the roll of webbing on the tube ready for the rolling up machine, to take it off through the tube (thereby turning the web) and roll it up again. This is a satisfactory device for putting the webbing on the turning tubes.

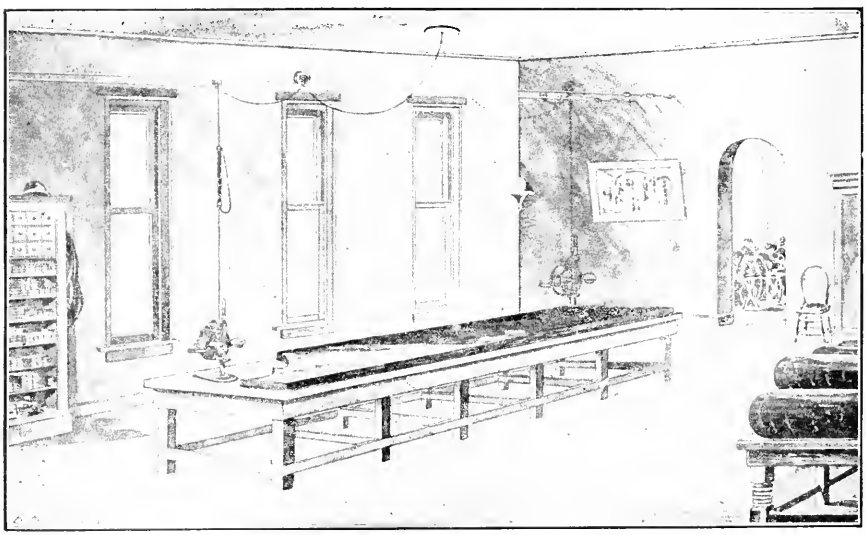


Fig. 3. Eastman Electric Cloth Cutting Machine Table.

Cutting to Shape. The cloth, now being right side out, is turned over to the cutter, who pushes an iron rod through the center, and places it in a rack, provided for that purpose, at the head of the cutting table.

If the cutting is done in the old way with a large, long knife pushed up and down through a slot in the table arranged to suit the size and style of the garment required, the cutter draws from the roll such a length as he requires, cuts it off, and repeats the operation until he has as many lengths in a pile, evenly distributed on top

of each other on the cutting table, as he may desire. After marking the top of the pile with a pattern corresponding with the slot in the table, he proceeds to "whip-saw" or cut out the sections of the garment as marked out with the pattern. The smaller sections are cut and fashioned with hand-shears, as also are the shoulders "sloped" where the sleeves are to be fitted in.

Finishing Processes. After a dozen bodies, twenty-four sleeves, twenty-four cuffs and twenty-four half borders have been prepared, they are tied up in dozen lots and turned over to the loopers, who loop on or join the cuffs to the bodies, the rib-tails to the bottom of the shirts, and join the shoulders without leaving a seam, as they are joined loop for loop in a manner not easily detected. They may be sewed together very nicely, but the point of joining is never so smooth and sightly as by the looping process.

The seamers then take the garments in hand to seam up the sleeves and join them to the bodies. The inspectors and menders then look them over and attend to what mending is necessary.

If overseaming the cuffs is in vogue the garments then go to the overseaming machines, to have the cuffs and half borders joined on the edges, after which they go to the washroom and are scoured and fulled. If they are to be bleached they are placed in the bleach house over night wet, and are given a sulphur bleach, taken out in the morning, rinsed and sent to the boarding room where they are boarded on forms of the proper size as designated by the yarn marks in the garments.

After drying out in the dry room or drying machine, and removed from the boards, the garments are sent to the finishing room where the process of finishing begins by girls looking over them to see if the sizes are properly sorted, and stamping the sizes on the skirt of each garment, attaching the Stetson coupon tag and sending them to the neck marker, who marks the neck with a "kicker," or in an up-to-date mill with a power marker.

After the neck flaps are cut the stitcher performs her operation of stitching down the flaps, and takes off the first coupon, it being the first piece-work performed on the garments. They are now carried to a cutting table, the fronts marked, cut down for the button stays and button hole facings, and are then turned over to the facer, who sews on the facing, detaches her coupon from the tag, and

passes them over to the twin-needle machine operator, who covers the raw edges of the flaps. The dozen then goes to the finishers, who put on the button stays and further complete the garment with binding of such quality as designated on the stub end of the check.

The button-holer now takes the dozen in hand and makes the button holes, spacing them and trimming off the threads. She turns them over to a little girl who marks them for the buttons and carries them to the button-sewing machine, where the buttons are sewed on and the threads trimmed off.

They now come under the eyes of the inspectors, or lookers-over, who look them over carefully, trim off all loose threads and shaking each garment, send them to the press-room, where they are carefully folded in papers or press boards in dozen packages and put into the press, in which they are left for three hours under a pressure of 3000 pounds or more. After being taken out of the press and the press-boards removed, they are carefully scanned by girls, who throw out all imperfect goods and fold the perfects or *firsts*, in proper shape to fit the boxes, after which they are boxed and labelled, ready for the shipper. A well regulated and well managed mill ought not to have more than $2\frac{1}{2}$ per cent of seconds, even on a medium grade of goods.

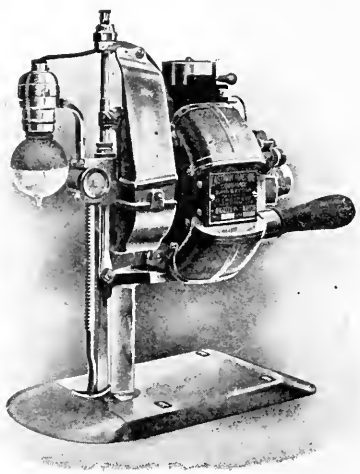


Fig. 4. Eastman Electric Cloth Cutting Machine.

Equipment and Arrangement of the Finishing Room. A well equipped, up-to-date mill today has several features in the finishing department that the larger number of the mills have been slow to adopt. In these improvements are included an electric or power cutting machine, taking the place of the old way of cutting with a knife following a slot in the cutting bench and pushing by hand with

an up and down motion as with a saw. Another departure is in the method of drying, a complete drying machine being substituted for the old way of a large room given up to drying and wasting heat.

The arrangement of the tables—cutting, inspectors', makers', and other tables as well as the machine tables—depends greatly on the size of the finishing room. The cutting tables should be in close proximity to the knitting frames. If the cutting is done on a floor

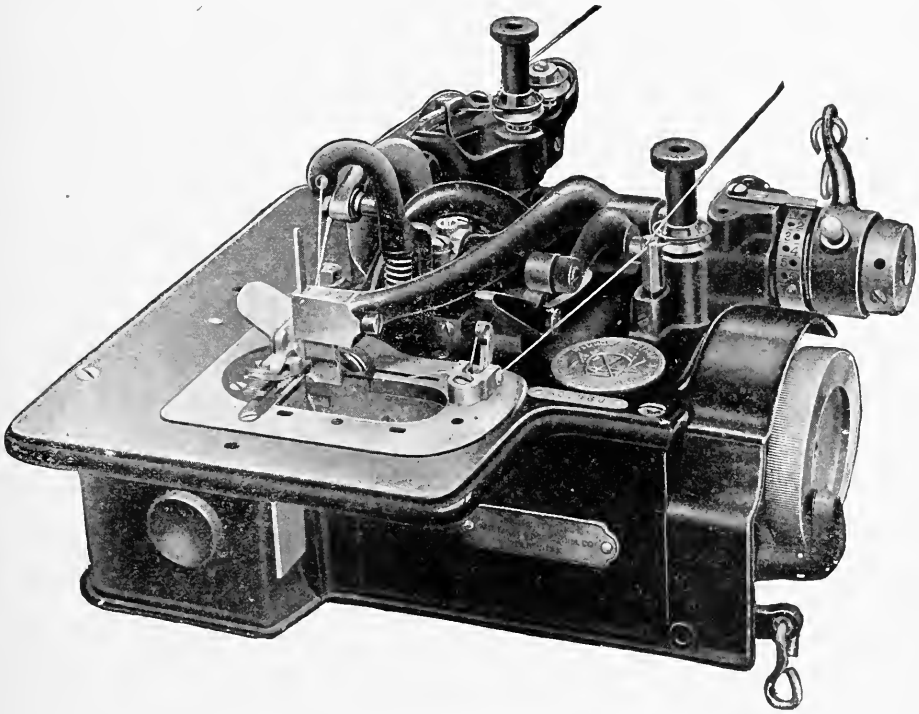


Fig. 5. Willcox & Gibbs "Overlock" Machine.

above that where the loopers are, a chute can be arranged to slide the goods down near the loopers after they are cut and bundled in dozens. To each bundle should be attached a patent tag, on which is printed a coupon for every operator who works by the piece to detach, in order to show the number of dozens she has done. The cutting may be done in the finishing room, if more convenient on account of the floor space. If there is space in the knitting room, it

is more desirable to do the cutting there, the rolls of cloth being more awkward to handle than the bundled dozens.

The seamers should be near the loopers. The nearer all these several operations are to each other, the less day-help is required to handle the goods, and it is folly to have operators of machines running after their work while their machines lie idle. It simply means more machines and more operators, and it is wiser in more ways than one to have little girls do what marking, and other preparatory work which they are capable of doing, carrying the work to the operators and taking it away, thereby getting the full production from machines.

EQUIPMENT FOR FINISHING 100 DOZEN FLAT GOODS WILLCOX AND GIBBS SYSTEM

A good finishing equipment for finishing 100 dozen men's or ladies' fine underwear flat goods, embodying the "Overlock" seam and hem of the Willcox & Gibbs Co., may be as follows:

One electric or power cloth cutting machine, with shirt and drawer patterns.

Eight Beattie double or lock-stitch loopers.

Three Wilcox & Gibbs "Overlock" machines.

Drying-boards; the number required depending upon the weight of goods and methods of drying.

One Kennedy's power neck marker.

Patterns and shears for trimming.

Six Willcox & Gibbs automatic finishers.

One catstitcher.

Six zigzag machines, for suspender tapes and covering gussets of drawers and covering edges of cloth left after running necks.

One button-hole machine.

One button sewing machine.

Three two-needle machines, for double row of stitching on outside.

One single-needle machine.

One Crawford power or hydraulic steam press, with press boards.

One rib cutter.

One Kennedy automatic band cutting machine.

One irregular form-cutting machine, with dies for irregular shapes.

One paper cutting machine for cutting domets, etc., into strips, stays, bands, etc.

One power eyeletting machine, for setting metal eyelets in drawers.

If the drawers have straps on the back with two sets of buttons and button-holes to change the waist size, no eyelet machinery is needed. If a tape or lacing is used, the eyelet may be either a metal

eyelet or stitched eyelet, the former calling for a power eyeletting machine, the latter for an eyelet stitching machine.

It is still a custom in some mills to use end-sewing machines to close the cuffs and anklets, but this is not necessary, the present methods of making the seams closing the cuffs properly.

UNION SPECIAL SYSTEM

An equipment for finishing 100 dozen men's or ladies' fine underwear, flat goods, say half shirts and half drawers, on the Union

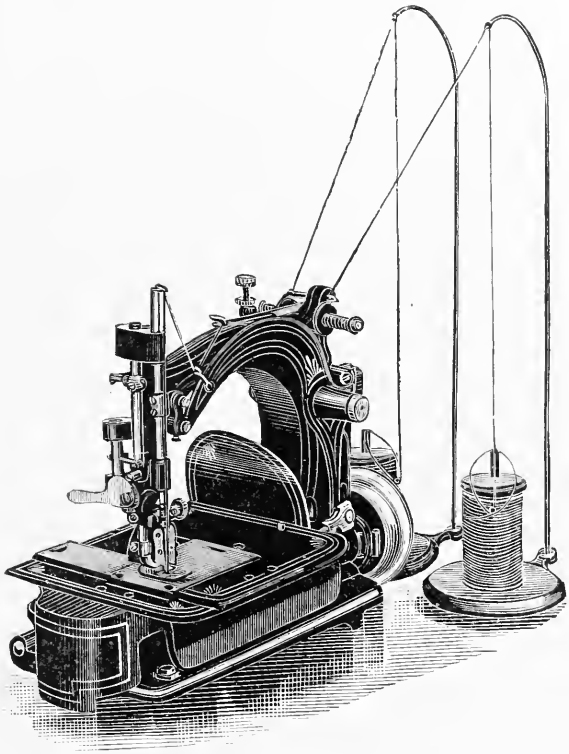


Fig. 6. Dewees Seaming and Trimming Machine.

Special system, should have the following machinery, although, of course, the weight of the goods may make a slight difference:

One electric or power cloth cutting machine, with patterns.
Eight Beattie loopers or turning off machines.
Three Union Special seamers.
Drying boards—the character of work will determine the number.

One Kennedy power neck marker.
Patterns and shears for trimming.
Five Union Special finishing machines for shirts.
Six Union Special drawer finishing machines.
One catstitching machine.
One button-hole machine.
One button sewing machine.
One strapping machine, for sewing suspender straps to drawers.
One Union Special single needle ornamental machine, for making pearl edge on binding.
One eyelet sewing machine, for stitching round eyelets, or one power eyeletting machine for metal eyelets.
One Union Special two-line taping machine, for covering back seam of drawers with tape.
One band stitcher, for stitching drawer bands together.
One twin-needle machine for necking.
One McCreary rib cutter.
One Kennedy automatic band cutting machine, for stays and facings.
One Gem paper cutting machine for cutting flannels domet, etc., into strips.
One Kennedy power cutter, with dies for irregular shapes, for cutting stays, drawer bands, forms, gussets, etc.
One Crawford power steam press, with press boards.

The Finishing Machine Table. Because of the exacting requirements now existing in high-speed sewing machines, it will be realized how vitally necessary it is to the most effectual performance of these machines, and to prolong their usefulness, that a solid support or foundation should be provided. Too often it is the case that the sewing machines are neglected with the result that their full efficiency is never obtained, and they must be overhauled much sooner than would be necessary if the table were of substantial construction, and the transmitters, shafting and pulleys supported and aligned in a workmanlike manner.

Of the sewing machines in use at the present time, the greatest number are either necessarily complex in their construction, and consequently of considerable weight, or are run at a high rate of speed, which is often more than equivalent to the weight factor in its ultimate effect on the table. Many machines combine both these features—weight and speed—which, of course, means a double tax on their supporting structure.

That class of machines which includes those used for button-holing, button-sewing, and strapping, is an example of the heavy type, and their most important function is the stop-motion which

is made necessary by the nature of their particular operations. These machines are run at a comparatively slow speed, but the unremitting succession of shocks from the stop-motion is a factor which imposes the hardest kind of service on the table.

All seaming machines, and some of those used for finishing are comparatively lighter than the class just mentioned, but the load which they contribute is added to by the high speed which is required from them. About the only machines in use at the present period that may be called *light*, as well as light running, are the small, single-thread finishing machines, and if those were the only ones to

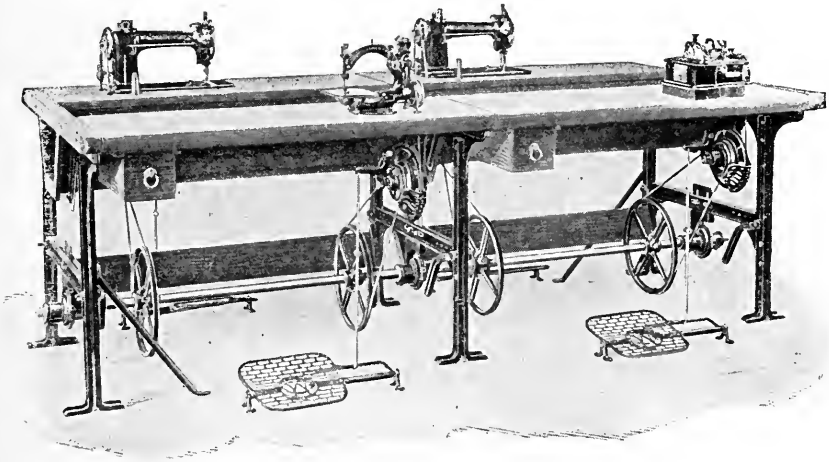


Fig. 7. Willcox & Gibbs Sewing Machine Table.

contend with, the ordinary light, wooden table would no doubt suffice.

Recognizing the requirements as they now exist, however, it becomes most important to consider them carefully, and provide a foundation for the machines that will meet the new conditions, not only with reference to the essential of convenience, but especially in regard to the required amount of strength and stiffness to adequately absorb any amount of vibration that may develop. The result would insure increased general efficiency of the machines, their usefulness would be prolonged indefinitely, and the table itself would be practically indestructible.

There are, of course, many differing ideas as to how a table should be constructed. A strong, wooden table has many good points, and so has one with iron legs and wooden top. The latter meets with the most general favor, however, and seems to embody a greater number of desirable features than any other. With reference to this subject a set of drawings has been prepared (See Fig. 8) that illustrates several views of a table which is designed to embody, in the simplest form, many features that have been proven to be essential, together with others that are somewhat novel; and it is believed that a combination of this description would effectually meet all of the essential conditions that may arise. The design is susceptible of modifications to suit the individual needs of each mill, or as the course of the product through each department may necessitate, but the general scheme will be readily understood.

In this table the legs are of cast iron, the main feature of which is a straight, tubular form of post that is designed to be located as nearly as possible under the point of load or stress which the table top receives from each line of machines, thus securing the most direct support and connection between the machine bases and the floor. The feet of these posts are extended horizontally from opposite sides of each post in a line parallel with the length of the table, and in this manner assist materially as braces in this direction. Strong lag screws which enter the joists or stringers where possible ensure a most effectual fastening to the floor at these points.

A feature which is second in importance only to a good floor fastening is that of supporting the main shaft in its bearings, for in a long stretch of table the corresponding length of shaft must carry a considerable weight of iron in the form of pulleys and couplings, and as this factor is always greatly exceeded by that of the straining belts, which are necessarily short and must therefore be kept at a tight tension in order to transmit the required amount of power to each machine, the resultant of these two forces, weight and strain, becomes of great moment.

To provide an adequate resistance against these forces at this point, therefore, it will be noticed in the drawings that the main, or lower cross rail web has been quite heavily ribbed both top and bottom, making it of the I beam form in section. In addition to this provision for strength in the rail itself, its ends are seen to depend

gradually to their points of connection with each tubular upright member, thus giving the rail an arch form in outline, and providing ample strength for its purpose in any direction.

The well known provision for adjusting each hanger in its rail for the purpose of aligning the shaft is shown in section.

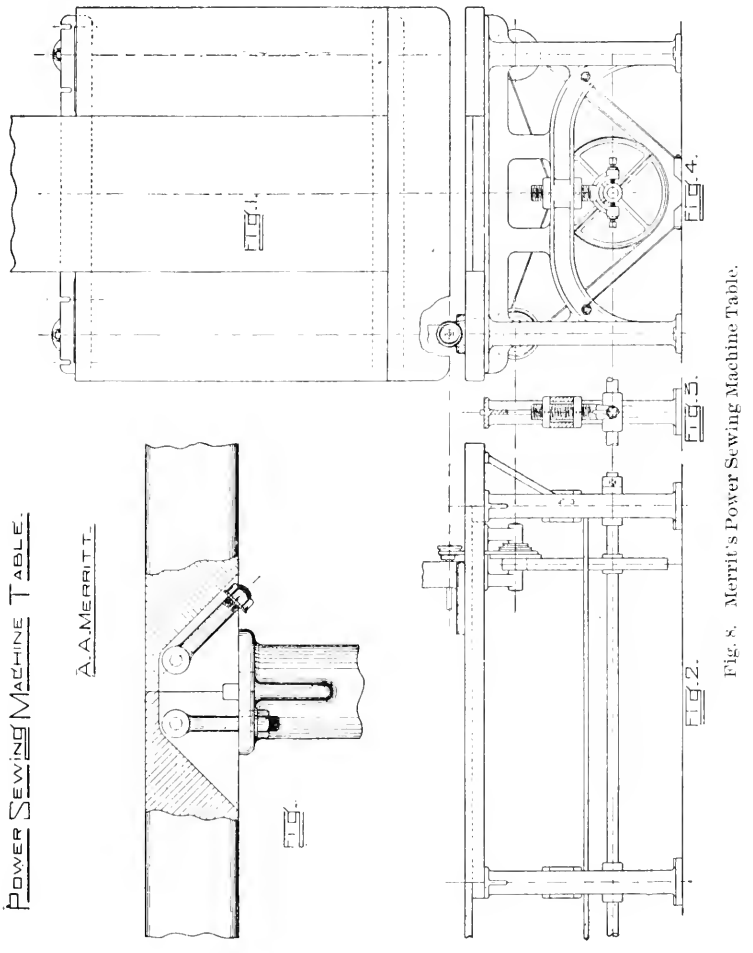
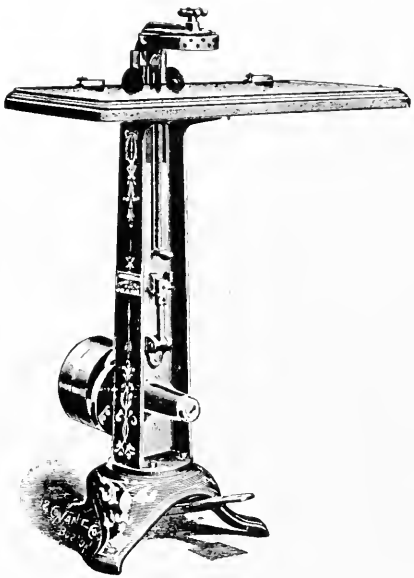


Fig. 8. Merrit's Power Sewing Machine Table.

The upper cross rail which supports the wooden top, is provided with a wide flange on its upper edge, through which the screws that secure the top are passed. Its mid-section is supported through two extensions of the web which connect respectively at two points on the

upper side of the lower rail. Both these rails and the two tubular upright members are combined in one integral casting, and there are no joints for the purpose of adjustment whatever, excepting the one for the purpose of aligning the shaft.

It is no doubt convenient, and sometimes necessary, that vertical adjustment for the table's top be provided, but where it is not necessary, it is doubtful if this provision is a practical one, for if not fastened very securely, such adjustable joints are soon out of place, and the table's top deflected thereby as badly, or worse, than any floor would settle in years. So if a table can be erected without them, it would be rigid to the utmost limit, and, thereafter, never need attention except as the building itself might change, and in that event any change would affect all points of the table equally, so if the shaft and the top were originally in perfect alignment their relation would never change.



Kennedy's Power Neck Marker.

A section of the top is shown, the central portion of which is made of one-inch stock, approximately, and extends continuously over as many pairs of legs, or supports, as its original length will permit. The two outer parts of each section, however, are intended to be of much thicker stock—say three inches—and will extend only from one leg to the next adjacent one, thus providing a separate top section or base for each machine and its transmitter.

The ends of these short sections are designed to rest on the upper horizontal flanges of the two adjacent cast iron legs in such a manner that two of the tops will meet and make a joint in the centre of one flange, and, if suitable detachable fastenings are provided, it is possible to remove any section with its machine and transmitter undis-

turbed, and replace them between any other pair of legs. This makes it possible to quickly substitute one machine for another at any point on either side of the table whenever it is found necessary or desirable to change the order of operations through the department, and not be obliged to pass the dozens back, or cross the table.

A trough or depression in the top has not been provided in this table, for the reason that this feature has always seemed to disclose as many defects as advantages, mainly in the fact that it was a very convenient receptacle for many forms of waste material, such as poorly wound cones of thread, or bobbins, defective binding, dirt, etc.

One other item in the table's equipment is that of supporting the spools or cones in a position that will most favorably deliver their thread to the machines. This position would seem to be somewhere overhead, but within easy reach of the operatives, and a long central rack may be provided for the purpose, which would be supported at intervals from the table's top, or suspended form the ceiling. The latter plan would be preferable as the rack would not then be affected by any vibration from the machines through the table.

ADJUSTMENT AND OPERATION OF FINISHING MACHINES

The adjustment of sewing machines is an operation which requires great care. If a machine is acting badly, an intelligent study of its condition is absolutely necessary before a move to correct it can be made Then, and not until then, can a remedy be applied with any hope of success.

General Consideration. So much has been done with sewing machines, and their various applications and forms of construction are so different, that it is hardly possible to group them, nor is it necessary. In nearly all the main functions are identical in principal, and before we take up each one separately, it is well to consider them generally.

Nearly all sewing machines have the combination of a *needle*; a throat or cloth plate, through which the needle passes after piercing the goods, a needle thread loop-laking device, and some form of feed. The needle must descend, or pass its point by the looper's point far enough and quickly enough to act in time for the looper to take the needle's thread, as soon as the needle's upward movement forms a loop, and the feed must do its work while the needle is out of the goods.

In feeding an ordinary piece of material on a plain machine, it can be generally stated that the feed must move laterally to carry the goods as much as is possible while it is above the plate, that is, have it appear above the plate as soon as possible after the needle has left the work, so as to have nearly all of its work done before it has to descend again, thereby getting the greatest amount of effective motion

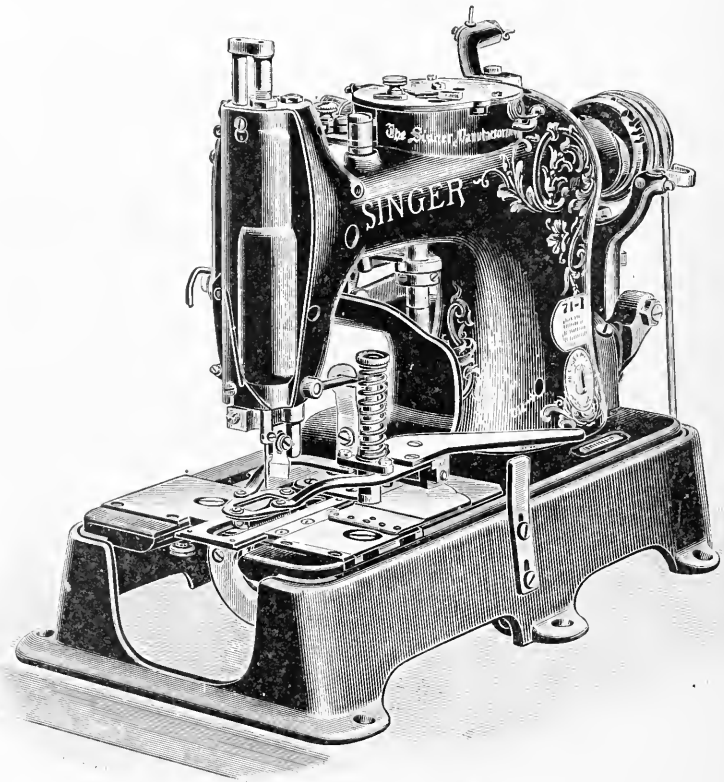


Fig. 9. Singer Button Hole Machine.

with the least amount of actual motion; for the four motion feed actuated by eccentrics (the easiest device known for high speed) cannot be made to take the ideal path, but takes the form of an ellipse.. The ideal path would be a parallelogram. This could be obtained by having the raising motion take place before any lateral motion above the plate, and the drop motion before the return below, but it is not suitable for high speed, because the sources of motion would

need to be intermittent, one waiting for the other, and obtainable only with some form of cams, which are hard in their action and lack effective means for taking up wear. Thread controlling devices, such as takeups, and, of course, tensions, are common to all machines; and no small part of the adjusters' art is needed to properly manipulate these inoffensive appearing but highly necessary parts of the general whole.

Plain Finishing Machines. The plainest form of sewing machines embraces the Willcox & Gibbs and Union Special types. They are one needle, single-thread, chain stitch machines in the high-speed class; and on work where this form of stitch is acceptable are very

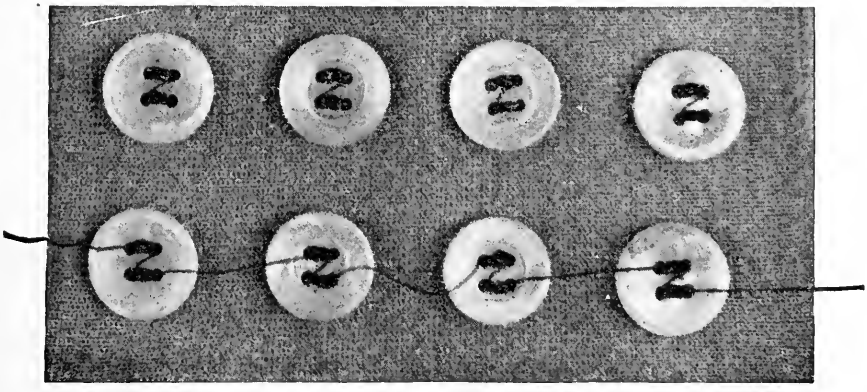


Fig. 10. Buttons Sewed on by Machine. The New Way (trimmed) and the Old Way (untrimmed).

economical, not only on the question of thread, but as to their ease of manipulation by the operator, and small number and simplicity of parts. When once in good working order they rarely need the attention of the adjuster, and when trouble occurs it is easily located.

The Needle. It is realized that the item of expense for sewing machine needles is large, and the practice of saving those which have been discarded and sorting the seemingly good ones out for use a second time, is perhaps an economy in some cases. The evils which an imperfect needle can cause are so many however, that it is of the greatest importance to make sure that this implement is not at fault.

An intimate and extensive knowledge of sewing machines and their habits has proved conclusively that it is a wise plan not to use

a needle a second time. If a machine is breaking more needles than it should, there must be some wrong condition of adjustment. This should be looked for and corrected.

The Looper. Having made sure of a good needle, the looper, or hook, must be examined and made perfectly smooth with crocus cloth. The point must be especially smooth and of the proper shape. If it has been broken or worn blunt, a careful grinding or stoning will restore it to the most favorable condition for taking a loop. If this process has shortened the length of the point materially, it may be necessary to change the spot on the shank so as to time the looper a trifle quicker.

In the Union Special type the looper may be quickened by lengthening its driving rod. As the point of a looper will allow of but little remaking this should be done with great care, for if too much is taken off it is useless. It may also be found that the thread has worn a groove, or crease, in the neck of the looper, where the loop, in the course of forming the stitch, comes to a rest. This may be the cause of breakage, and many times can be stoned out without changing its effective form.

In the Union Special type of machine the loop-retaining wire on the under-side of the throat plate must be looked at, and if rough, it also should be smoothed with crocus cloth. This part is adjusted so that the looper in its action travels very close to it. If it has by any chance become bent, so the looper rubs it, breakage of thread is sure to follow, either by being pinched off between the two parts, or by their roughness from the too close contact.

Before the machine is ready for a test, look over all the eyelets or guiding holes through which the thread passes. These must be smooth and round, that is, they should not have sharp corners over which the thread, in passing or being drawn up, will be compelled to take a sharp angle. If a groove or crease has worn in any of these, a new, smooth one is necessary. If a machine breaks the thread in the chain, the trouble is most likely with the feed, or presser-foot, perhaps both. The bottom of the presser foot must be smooth and have a bearing from end to end on the feed points. It should also rest its whole length on the throat plate when the feed is down. The needle hole and plate must also be examined for rough places.

The Feed. A feed that is new and excessively sharp, or one that has been worn dull, may cause a breaking of the thread. In the latter instance, the chain will not be fed away from the stitch-forming position positively enough. If a feed is too sharp, we have the emery and crocus cloth remedy. If dull, it can be annealed and the teeth refiled to their proper shape. Many times the sharp burrs or edges of feed points may be rubbed off with the wire side of a file card.

Skipping the Loop. The causes for skipping (or missing) stitches generally lie in the needle and looper. If this is the trouble, first make sure that the machine is threaded properly. Then see that the needle in raising throws out its loop favorably for the looper point to enter. If the loop is not large enough, try the needle a little lower still, say one-sixteenth of an inch. If not enough, then try it a little lower still. It is not best to have the eye of the needle over one-eighth of an inch below the under-side of the looper point when the needle is at its lowest position, and this may be considered the most favorable condition in nearly all cases. The exceptions might be when unusually hard or soft material is being sewed; and if, after trial, a lower position of the needle seems better, it will probably be necessary to make the time of the looper a little slower, thereby allowing the lowered needle time to rise and open out its loop before the looper point gets to it.

If the loop does not open out squarely before the looper point, the needle may be turned in its holder, or if it is spotted in the needle bar, the bar may be turned in the required direction to make the loop open favorably.

Loopers having short, slim points should be set so as to pass by the needle very closely, but not touch it, for, as a rule, the needles in such machines throw a comparatively small loop. In machines which carry a broad, longer looper, it will be found that the needle's eye is driven farther below the looper point, and has more of an upward movement before the looper point gets to it than is the case with the other. The vibratory type of looper may be set quite close to the needle on its forward, or loop-entering stroke, and as close to the needle on the return, or backward, stroke as is possible and touch it. These adjustments of the looper in relation to the loop retainer are quite vital points, and it is essential to have them correct before much else is done.

Skipping of stitches and thread-breaking can often be traced to poorly working tensions. The thread friction discs must always be free to move on the post and be clear of lint. If the thread has worn creases in the faces of the discs, they will not control the thread evenly. The spring also must be of the proper strength, yet perfectly flexible. If, having exhausted our list of remedies, the thread still persists in breaking, it is but fair that the quality of the thread be considered, for a small proportion of the thread which is made will not run on any machine, and it becomes a useless expenditure of time to try to make it do so.

High Speed. The matter of speed also is to be considered. Beyond a certain limit in every machine, excessive speed is actually more detrimental to a manufacturer's interests than too little, for once let a machine become racked and worn from this cause, its usefulness is over, and repeated overhaulings become more and more necessary. In response to the user's standing request for high-speed machines, the designer's work is constantly carried on with this as one of the important ends in view, and no doubt time will produce machines capable of 4,000 and even 5,000 revolutions per minute.

Two Thread Finishing Machines. In taking up for consideration those sewing machines which use two threads in making their stitch, we enter a more interesting and instructive department of the whole sewing machine art and applications, and it is especially interesting when considered in connection with the manufacture of knit goods, for the very peculiar nature of this fabric at once prohibits the use of a stitch that might be perfectly satisfactory on goods of a firm texture. We may know this from the fact that thousands of machines which make the familiar two-thread, so-called lock stitch, with a shuttle and bobbin, are employed exclusively in making up our heavier outer garments, and also underwear, which is made from muslin and linen. These fabrics all are of a firm and non-elastic nature, so there need be no different element required in the sewing stitch which enters so largely into their construction, and consequently the lock stitch suffices, or rather we may say, it is necessary and therefore satisfactory.

Elasticity in the Seam. When our modern knitted fabric, with its beautiful and distinctive feature—elasticity—was invented, the question of garment making from it on sewing machines became a

vital and puzzling one, and especially was this the fact in the matter of seaming or joining the parts together, for if the old lock stitch was introduced for this purpose the non-elastic nature of it at once destroyed the very feature that brought this fabric into existence. From the very first, this stitch seems never to have been considered except in one or two impractical ways, and the only other recourse was to some form of chain stitch, and up to date but three forms of it have ever been used.

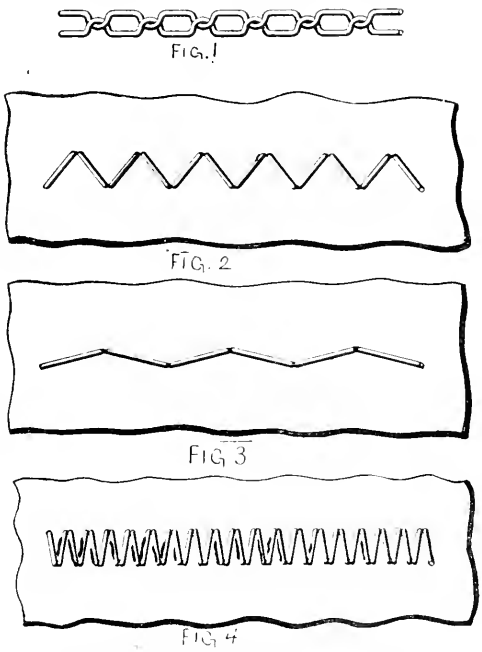


Fig. 10. Diagrams of the Lock Stitch.

First, and for many years, it was the single-thread chain stitch with which all seaming, as well as finishing, was done, and we may take it for granted that this seam met all early requirements, but as the fabric was improved in texture, quality and finish, each succeeding year, the single-thread chain stitch became deficient in many respects, and was finally supplanted by the two-thread chain, or double-locked stitch. This stitch was first made by what we knew as the Grover & Baker machine, and was a long step in advance of the single-thread chain stitch, because the second or additional thread not only doubled the seam's strength, but the manner in which the two threads were looped or interlaced with each other, produced a greater degree of elasticity —two elements which we know are of vital importance.

THE LOCK STITCH, DOUBLE CHAIN STITCH AND "OVERLOCK" STITCH

Sewing machines which use two threads in making their stitch may be grouped in three classes—the *lock stitch*, the *double chain stitch*, and what is known as the *overlock stitch*.

Lock Stitch. The first, or lock-stitch, shown in Fig. 11, is the oldest form of the three. It is not used in the actual making of a garment from knit goods to any great extent, owing to its lack of elasticity, that is, it will not yield when the goods are stretched without breaking apart. This, of course, precludes its use for such a purpose. It can be, and is used in button-hole, button-sewing, over-seaming and cat-stitching machines, and in these operations it is perfectly satisfactory. In button-holing and button-sewing the stitches are confined to particular places on the garment and are not continuous as in a seam, so the element of elasticity is not required. In over-seaming and cat-stitching, however, this stitch must be elastic, and as it is used in these operations it is so from the fact that the machines are constructed so as to lay the threads on the two surfaces of the material in a succession of diagonal stitches, as illustrated in Figs. 2 and 4, and when the fabric is stretched these diagonal stitches change their position to make an approximately straight line, something like Fig. 3 in appearance.

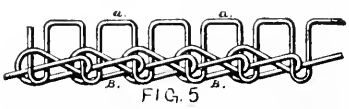


Fig. 12. Double Thread Chain Stitch.

Different degrees of elasticity may be obtained by adjusting the machine to sew a varying number of stitches in a given distance. For instance, a seam having twelve stitches to one inch, will be much more elastic than one having four stitches in the same distance. There is no way by which this stitch can practically be made to produce an elastic straight-away seam, so if this is desired a lock-stitch cannot be considered.

Double Chain Stitch. The second, or double-chain stitch, is much more elastic than the lock-stitch, and is, therefore, peculiarly adapted for use in making garments from knit goods or any material of that nature. It is elastic for the reason that a surplus length of thread is introduced into each stitch, both in the knot or tie of the two threads together, and as it is laid on the surface of the material between the successive needle punctures.

The excess of needle thread is obtained from the fact that the tie or connection of this thread with the under or looper thread is always made on the lower surface of the work, so, instead of lying in a comparatively straight line, as it does in a lock stitch, it must pass

through the material to its tying position with the under thread, and then back again to the upper surface at each puncture of the needle. The position of this thread as it lies in the stitch is shown at A, Fig. 12.

A surplus of under thread is obtained in this stitch from a process of weaving or looping from stitch to stitch, which gives it a total of three times the length of the stitch itself; that is, there are three strands of thread laid on the under-surface from one lock to another. A close examination of a seam of this character will show the course of this thread quite plainly. It is illustrated at B in Fig. 12. In this manner both of the threads are given a greater length than the seam itself, and produce the necessary amount of elasticity. Of course, all of this elastic element may be eliminated from the stitch by excessively tight tensions, and it therefore follows that more or less may be obtained as required from the same agency.

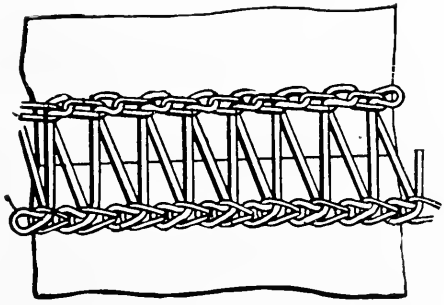


Fig. 13. Diagram of Covering Stitch.

"Overlock" Stitch. The "overlock" stitch is the most elastic of all, and its distinctive feature is that it is, in addition to this, a very efficient covering or wrapping stitch. This makes it valuable for edge-finishing, or selvedging, as well as for seaming, and when used for seaming the result is a beautifully-finished, even and perfectly elastic joint of the two parts of the garment, the edges of which are neatly covered and protected from wear. The elasticity of this stitch is obtained by laying so much of its thread, both upper and under, across the line of the seam.

Another advantage which the double chain and the overlock stitches have over the lock stitch is that the thread may be used directly from large spools or cones, for unlike the lock stitch, the spool-end of the looper or under thread is never passed through the needle loop but the two threads are locked or laced together from stitch to stitch, similar to a knitting stitch or crocheting. This does away with the necessity of bobbins for the under-thread, on which

the number of yards which may be wound is always limited, owing to the fact that the whole functional group, thread, bobbin, and bobbin-case, must be passed entirely through the needle thread loop for each stitch.

In the chain and overlock stitches only a very little more thread is drawn from the needle than is actually required to make the stitch when it is finally set in position, so that no great unused surplus must

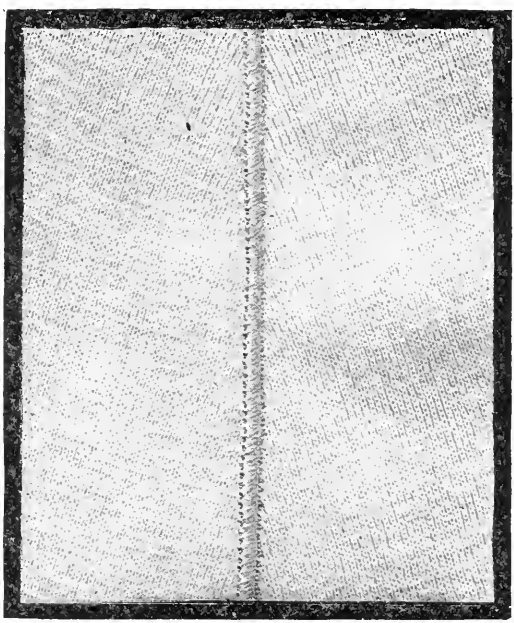


Fig. 14. "Overlock" Seam for Sleeves.

needs be taken back through the eye of the needle by the moving eyelets. For this reason, the thread is not served back and forth so much, and thereby frayed or weakened before finally laid in the stitch.

In referring to the accompanying diagrams it must be borne in mind that they are greatly enlarged, and the positions of the several threads are considerably distorted in order to show more plainly their relation to one another. In actual practice a machine with properly adjusted tensions and correctly operating stitch-forming implements will produce a perfectly smooth and even stitch which can be stronger than the fabric itself, given the proper quality of thread.

Tension. The matter of tensions is a very important one in all sewing machines, and we may say that it becomes more so as the speed

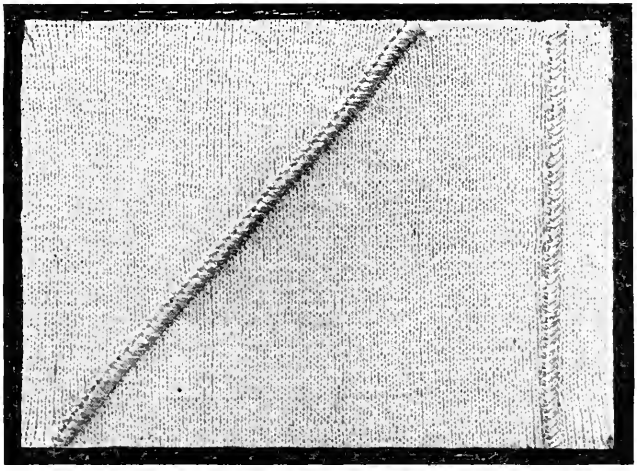


Fig. 15. "Overlock" Seam for Sides and Gussets.

factor is raised in each successive "new model" which is brought out,

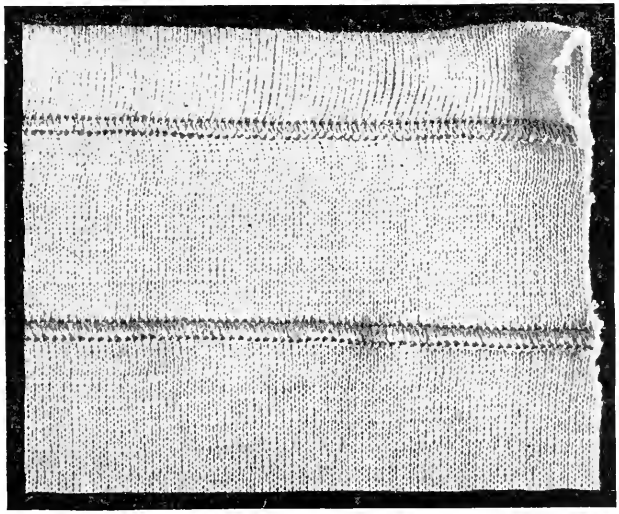


Fig. 16. "Overlock" Seam for Shoulders and "Overlock" Concealed Stitch Hem for Shirts and Cuffs.

for it must be borne in mind that the same functions exist and must be reckoned with in every kind of stitch, whether it is made at a low

or high rate of speed. One of these functions is that a never-varying quantity of thread must be measured off for final treatment by the stitch-forming implements, *i.e.*, the needle, looper, etc., in every individual stitch, and the problem is to produce an even stitch with the greatest amount of precision, and without applying any unnecessary friction on the several threads.

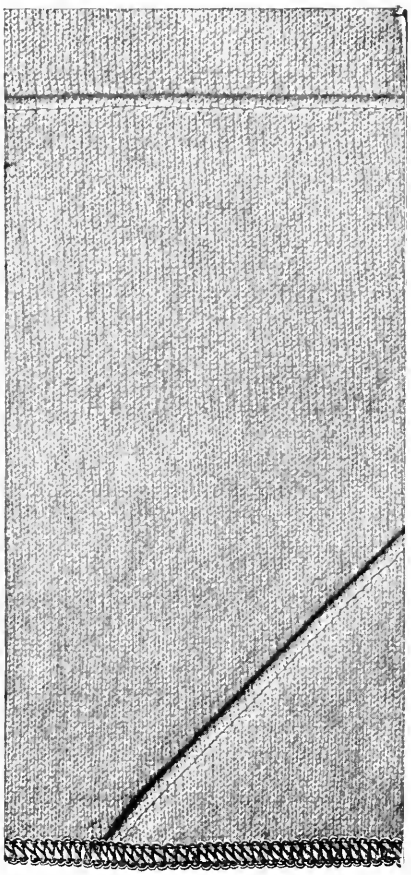


Fig. 17. "Overlock" Over-Edge for Shirts and Cuffs and "Overlock" Tailor-Made Seam for Shoulders and Gussets.

Trimming the Seam. Another element of great interest to us in the development of a sewed seam on this peculiar fabric is the inception and subsequent stages of improvement of the trimming devices which now are used in connection with the stitching mechanism.

Previous to 1880 the hand-sheared seam prevailed, but the inventive and ever alert minds of the sewing machine makers quickly saw an opportunity, and at once began to consider the feasibility of combining with the sewing mechanism an efficient trimming device which would perform its office simultaneously with the making of the seam, and thereby eliminate the slow, tedious operation of shearing the projecting surplus by hand. The first trimmer seems to have appeared about 1880, and was in the form of a circular disc with a portion of the disc left blank in order that the feed might operate freely. Other devices of minor importance followed at intervals, until the device which acted on the shear principle appeared. This

was practical and efficient, and was in use extensively for some years. Then came the trimmer, which operated with the abrasive process, and finally a machine was brought out which embraced in one complete whole the three elementary functions of sewing, trimming, and covering the seam at one time.

This brings us to the present day, and from all the various inventions for the purpose of trimming knit goods which we know of, but two of them have survived and are used to any great extent. These are the *abrasive trimmer*, which is used in conjunction with a machine making the two-thread, double-locked chain stitch we have already mentioned, and the *shear trimmer*, which is incorporated in the machine combining the three covered stitch functions. These two trimming devices have stood the test and proved to be very important agents in the process of making the two types of our present finely-developed, covered, elastic seam on knit goods.

The Union Special Dewees Trimmer. The Union Special seaming and trimming machine (shown in Fig. 6) was the result of a combination of the Union bag sewing machine and the Dewees trimmer, which was effected about 1885. The sewing stitch is the two-thread, double-locked chain mentioned above, and the trimmer is of the abrasive type.

This machine has stood the test of years as to strength, durability, speed, and general all-round efficiency. The trimming device is an original, unique, and effective one, requiring no sharpening of knives, is durable, can be operated at a high rate of speed, cuts a clean edge, and the amount of fabric beyond the seam can be regulated to suit any material. It will perform its work satisfactorily for days, with practically no attention whatever other than the ordinary oiling of its parts.

In the final development of the seam, after it has been seamed and trimmed, the garment is submitted to another operation, which employs one of the best designed Union Special machines. This is a side wheel cylinder, two-needle, three-thread machine, especially adapted to cover the trimmed seams on knitted fabrics. The cylinder is small and permits of covering the seam of a very small sleeve or leg. Two parallel rows of stitches appear on the upper surface of the material, (or outer side of garment) while on the lower surface of the material, (or inner side of garment) the rows of stitches are inter-

locked by a thread which entirely covers and draws down flat that portion of the fabric beyond the seam. This adds strength to the seams to a great degree, besides producing a very sightly and comfortable result.

The seam which is made on this system is one of the best which has ever been devised. It has great strength, each stitch being fastened independently as well as in combination, so that it cannot rip, and is very elastic. It is flat and smooth on both faces of the garment, thereby ensuring the greatest comfort to the wearer.

In adjusting the trimmer on the Union Special both upper and lower toggles must first be ground on a true circle with the center of each one, which is easily done on the small grinder furnished with this machine. The upper toggle should then be dressed to a small round on its circular edge, so that its contact with the lower toggle will be but a very narrow edge having no sharp corners. The lower toggle must be left straight or flat, across its circular edge to provide a smooth surface for its mate.

To adjust toggles, fasten the lower toggle in the toggle frame by its fulcrum and clamp screws, and see that it is at the proper height in relation to the feed, means for this purpose being provided by a wedge with thread and nut at one end which lie in the toggle frame beneath the fulcrum block. The height of this toggle should be with its circular edge about half-way between top of throat-plate and top of feed-dog when the latter is at its highest position; then fasten upper toggle in place and move it down to the lower one by means of its wedge, so that they touch each other. It may be found on testing them with a piece of cloth that they will need a trifle closer adjustment, but care must be taken that they do not press against each other any harder than is necessary to trim the cloth cleanly, for too much pressure will produce unnecessary wear and is liable to break the edges of the toggles.

To adjust for width of fabric beyond the seam, move the whole toggle frame to or from the needle or line of stitching, first loosening the screws which hold it to bed of machine and needle bar head. When the desired width is obtained be sure that all screws are tight.

To adjust needle with looper, when the needle bar is at its lowest point, and the looper is at its extreme backward throw, the point of the looper should be nine thirty-seconds of an inch from the needle,

and in its forward throw should pass the back side of needle as closely as possible and not touch it, and in its backward throw the needle should just clear the back side of looper. The adjustment of this rocking motion of looper is by means of set screws in the looper rock shaft fork which secures it to the rock shaft. The lateral adjustment of the looper is by the connecting rod from lower arm of needle bar lever to the looper holder. After loosening the check nuts at each end of this rod, which has a right and left hand thread at the ends, a slight turn in one direction or the other will move the looper to or from the needle. The needle should be adjusted with the deep groove towards the operator, and of such a height that the eye will be about three thirty-seconds of an inch below the looper when the latter's point is just back of the needle. In most cases this adjustment of needle and looper will ensure the most favorable conditions for taking the loops of thread, but some unusual conditions of thread or fabric may require a slight modification, and this must then become a matter of the adjuster's own judgment.

Tensions. In this machine the lower tension should be looser than the upper, but the proper adjustment of either one will be found to vary with the quality of fabric. That of a hard or non-elastic nature requires, and will stand, a tight tension, varying with the strength of the thread. In sewing on knit goods of an elastic nature, the object is, of course, to produce a seam which will be strong and at the same time just as elastic at the material itself, and it is obvious that the latter result cannot be obtained with too tight a tension. A good test to determine the proper position of the tensions is to examine the seams after sewing: if the seam gaps or opens on pulling the two pieces of cloth apart then tension is not tight enough, and if on pulling it lengthwise of the seam the threads break the tension is not loose enough.

Take-up. This part operates to take up the slack of, and cast off at the proper time, the lower or looper thread. The adjustment of the cast-off function will be found by raising or lowering the retaining wire, the points of which have their position in the central groove of take-up.

To Adjust Nipper Springs. These serve to hold the looper thread tighter than the tension discs will do at the time of setting the stitch; they should close and nip the thread just as the take-up comes

up between the thread eyelets and touches the thread; again, when the looper has reached the end of its backward throw and is ready to come back, the nipper string should be closed. If greater elasticity is desired, adjust the spring to nip a little later, by means of the adjusting screw in the lug directly underneath the free end of nipper spring. By raising or lowering this screw the nipper spring is made to nip the thread earlier or later, as desired. Both of these parts—take-up and

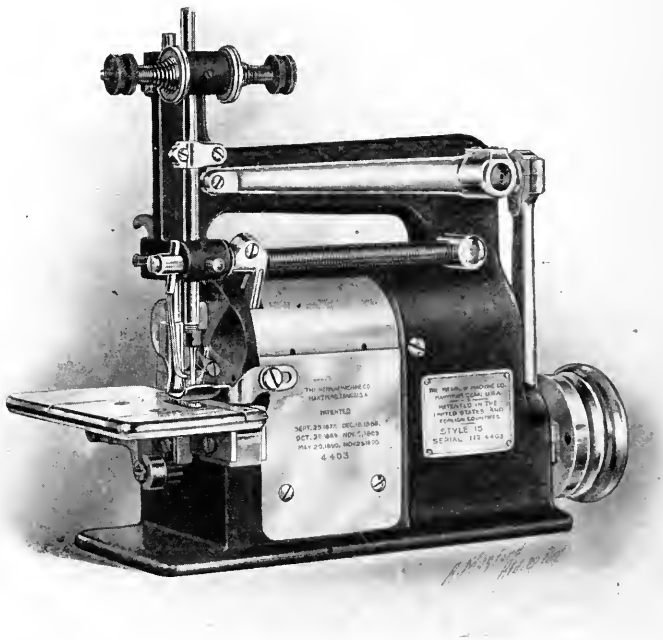


Fig. 18. Merrow Plain Crochet Machine.

nipper spring—are sensitive to a large degree, and should not be moved unless the adjuster is sure there is a reason for so doing.

The Willcox & Gibbs "Overlock" machine, (see Fig. 5) combines, in one complete whole, the necessary mechanism to produce in one operation a trimmed, joined, and covered seam, and makes the "Overlock" stitch. In appearance it is a radical departure from the long accepted type of sewing machine, chiefly owing to the absence of the familiar overhanging arm. This novel design is not unpleasing, however, and the machine is very strong and compact.

All the operating parts of the machine proper, are mounted on a single casting or frame, and this frame with its several mechanical functions is hinged to a plain box casting, which serves as a rigid base or support, and is also a receptacle for the oil which drips from the bearings, thus preventing an unsightly oil-soaked work table. This arrangement of the various parts makes them easily accessible, and all parts can be reached either from the top of the frame or from the under side, which is presented to view when the frame is raised up and backwards on its hinges.

Adjusting. On the subject of adjusting, in relation to this machine, there seems to be a scarcity of matter which may be said or written, for in its design several functions which in the ordinary sewing machine have a latitude of adjustment are here found to be positive and permit of no change whatever. About the only possible adjustments are those for the length of feed, or stitch, the width or bite of seam, or over-edge, and the lower trimmer blade; also to a limited extent the tensions. The take-up and pull-off functions are positive and admit of no change.

Tension. In all sewing machines there is probably no one feature so extremely sensitive, or which, if changed ever so slightly, produces poor results so quickly as the tensions. When trouble is traced to the tensions, the first act should be to draw the discs apart and blow out the lint so that the discs may come closely together and not be hindered, by bunches of lint, from pinching the threads and doing their full duty. Other than this, little trouble may be experienced with the tension mechanism.

With the "Overlock" machine all of the tension nuts are restricted in their movement to less than one full turn, so it is evident that no very great error can result from poor adjustment within this limit. Furthermore, as the pull-off and take-up functions are constructed, any degree of tension that may be necessary to meet the different requirements of the stitch on light to heavy fabrics are found within this comparatively small range of tension movement.

Width of Seam. The adjustment for width of trimming or bite has been made semi-automatic; that is, it is operative within certain predetermined limits at the will of the operator, and while the machine is in motion, This is accomplished in a very convenient manner by means of a treadle connection to the trimmer adjusting arm, which

when actuated serves to alter the position of the trimming parts in relation to the line of needle punctures.

This feature of the machine enables an operator to complete a garment with seams which vary in strength as required in different parts of the fabric. For example, a seam which is made along the side of a sleeve or drawer leg will be stronger than one made across the top or shoulder of a shirt, providing no change is made in the machine. In the first instance, the stitching is with the wale, or lengthwise of the fabric, where there is no tendency of the knitting

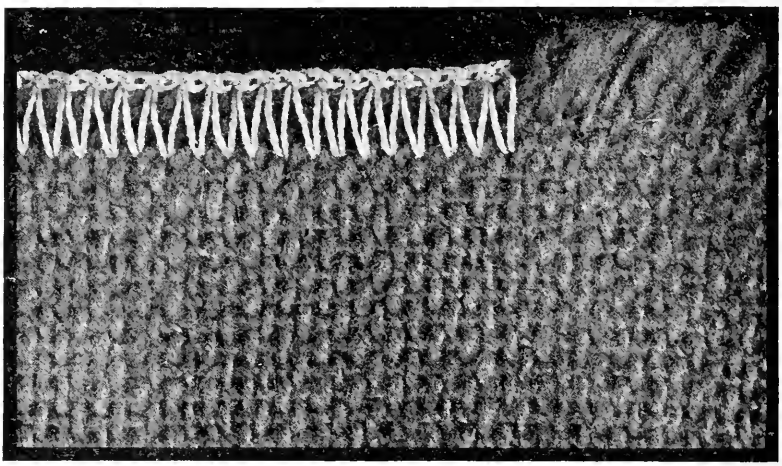


Fig. 19. Two-Thread Crochet Finish on Very Rough Edge.

stitches to ravel out, so that a minimum width of seam or trim can be employed.

In seaming across the top or shoulder, and around arm-holes or gussets, the stitching is laid either squarely or diagonally across the ends of the wales, where the knitting loops are exposed and extremely liable to unravel if not properly secured; therefore a wider seam is necessary. When it is desired to use this width-changing feature of the machine a thumb-pin is inserted in one of a series of holes in the trimmer-adjusting arm, back of a stationary stop, and when it is against the stop this pin is a limit for the narrow seam. Another thumb-pin placed in a hole in front of the stop, as far away as is necessary, to give the required change, will be a limit for a wide seam.

In operation this trimmer adjusting arm is held normally in position for a narrow seam by a spring, and when the treadle is depressed the trimming parts are moved to the position for a wide seam.

Setting the Trimmer. In setting the trimmer blades for seaming, the cutting edge of the lower blade should be adjusted even with the top of the throat-plate, or needle-hole piece. For concealed stitch hemming this blade must be a trifle higher, and for both purposes the cutting edge of the upper blade must pass by that of the lower one a sufficient distance to ensure clean cutting of the fabric. The position of the upper blade is determined by a stop, so there is small chance for error. It is very essential that the trimming blades should be

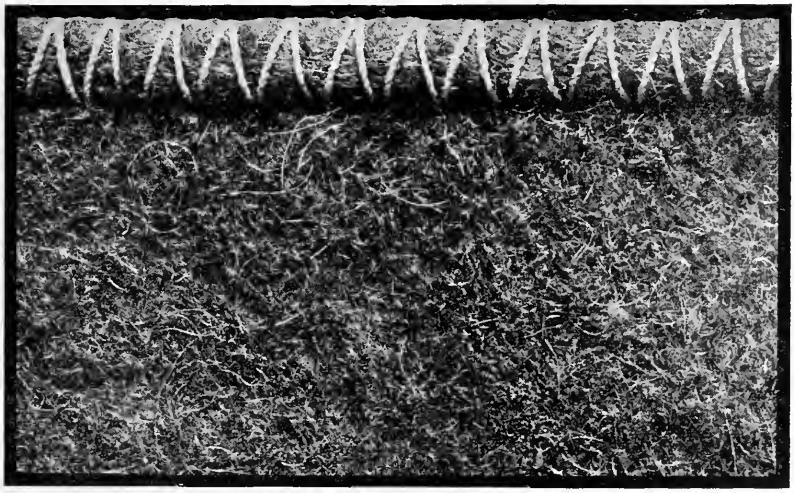


Fig. 20. Single Thread Crochet Finish, Hemming Edge.

kept sharp, for if they are allowed to become dull no end of annoyance and bad work will ensue.

Sharpening the Cutters. That the blades may be ground accurately there is furnished with each plant of "Overlock" machines a trimmer blade grinder. On the slide of this little machine a set of grooves has been milled to fit the respective upper and lower trimmer blades, and when in position the blades are held and presented to the emery wheel so as to give their cutting faces the proper angles. In shaping the ends of the blades be careful to have them fit the templets on the slide of blade grinder.

MERROW KNIT GOODS FINISHING MACHINES

The Merrow Plain Crochet Machines, a type of which is illustrated in Fig. 18, are made in several styles each adapted to produce a crochet finish upon the edges of various fabrics. Some of the finishes from the different styles of Plain Crochet Machines are illustrated in Figs. 19 and 20.

The Merrow Scallop or Shell Stitch Machine illustrated in Fig. 21 produces the two thread shell stitch finish about half an inch deep.

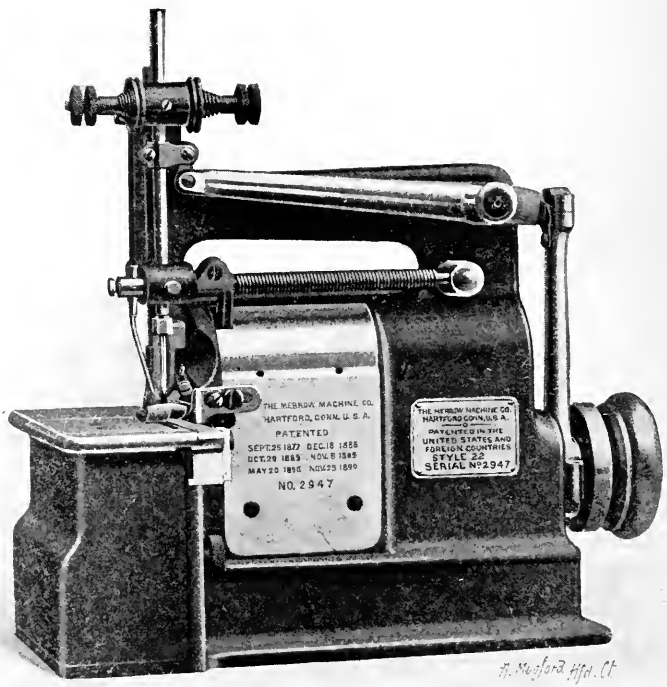


Fig. 21. Merrow Scallop or Shell Stitch Machine.

This finish is beautiful and substantial and is used upon a great variety of fabrics such as heavy knit goods, eiderdown garments, etc.

Fig. 22 represents the shell stitch finish, full size, as made by the machine on knit goods. This machine is used to produce shells of two, three or four stitches each as a foundation finish, upon the edge of which a smaller shell finish is later made by another style of shell machine.

The smaller shell finish made by a variety of this machine, upon the edge of knit goods, is used separately for binding the edges of

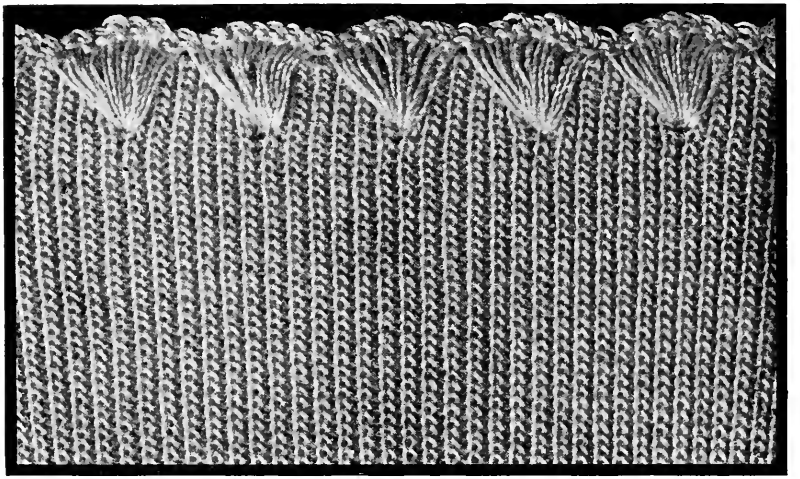


Fig. 22. Shell Stitch Finish, Full Size

light-weight goods. On many classes of knit underwear two or more

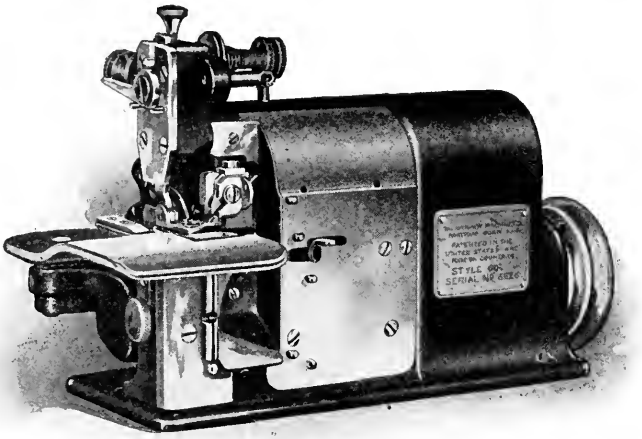


Fig. 23. Merrow Two-Thread Trimming and Over-Seaming Machine.

courses of this finish can be used to great advantage. Braid, tape or ribbon is sometimes drawn under the foundation finish.

The Merrow Two Thread Trimming and Overseaming Machine, illustrated in Fig. 23, is primarily designed for overseaming two or more pieces of fabric together, and is provided with trimming devices for cutting off the edges of the goods simultaneously, and in advance of the overseaming operation, when overseaming, and for trimming off the surplus material at the edge of the goods, when edging, and is also provided with devices for controlling the edge of the fabric in advance of the edging operation, and to facilitate the finishing of cuffs and other tubular goods. A variety of this machine produces a three thread overseam stitch which is especially desirable as an edge finish.

Another style of machine is for producing the blind stitch hem on the bottoms of shirts, etc., such as fleece-lined goods; while still another is especially adapted for producing the blind stitch hem upon the tops of stockings.

PLAIN FINISHING MACHINES

Operating and Adjusting. In the processes of trimming or finishing vests, shirts and drawers, the sewing machines used for these purposes, as well as those for the making or seaming operations, have now been brought to a high state of perfection, and the results obtained are very artistic and pleasing. While the obstacles to be overcome in this branch of the work are not so numerous or as difficult as in seaming, they are oftentimes troublesome, and the final appearance of the garment depends largely on the manner in which these machines are kept up to a proper performance of their work.

In a general way, a few points in these finishing operations may be mentioned which seem to need particular attention. In the matter of feeding, for instance, if the material comes out having a puckered appearance, either in stitching on the bands or facings, but especially in binding, a truly finished effect is absent, and the cause of such work may often be traced to a poorly-working feed. Again, a machine may be making an excessively coarse stitch, which on fine garments, especially, is very unsightly. This, of course, is easily remedied, and after the proper number of stitches to an inch is once decided upon, care should be taken to see that this standard is adhered to.

The size of the needle also plays a part in the general effect, for a needle which is larger than the thread calls for, leaves holes in the

comparatively hard facing or band fabric which the thread does not fill up properly, and oftentimes gives the impression that the holes have been made for rivets, with the rivets left out.

Another point which is more of an individual than general nature, depending largely on the character of stitch made by the machine in use, is the laying of the stitch on the under side of the fabric, or inside of the garment.

In every machine, whether it makes the lock, single chain or double chain stitch, there is a specific method of drawing up the thread on the under side, and perhaps this point in the adjustment of a machine may be called the most important of all, for the design of the whole machine is dependent and made subordinate to the one feature of making the stitch, and surely a sightly appearance on the reverse side is just as important as it is to have the upper side correct. Then, also, if either of the threads is not drawn up properly a greater quantity of thread than necessary is being used.

In the lock-stitch, which lays but a single thread on both sides, it is, of course, possible to obtain a like effect on the top and bottom, and that very easily, through the medium of tensions, provided all other functions of the machine are in normal condition. Owing to the old drawback, the winding of bobbins, always present in a machine of this kind, and their comparative slow speed, lock-stitch or shuttle machines are seldom used in finishing operations. It cannot be denied, however, that this stitch is strong enough for the purpose, not liable to ravel out, and presents a neat appearance on both sides of the fabric. Several of the concerns that build this class of machines have expended large amounts of money and inventive energy to overcome their inherent defects, and with considerable success. The Willcox & Gibbs, Standard, Wheeler & Wilson, and Singer companies have each recently brought out high-speed machines of this type, and in their design and construction several novel features have been introduced.

The Willcox & Gibbs Lock Stitch Machine. (Fig. 24.) The machine built by the Willcox & Gibbs Company is built on the well-known Willcox & Gibbs system, of the finest of material and workmanship, and is a long step forward in lock-stitch sewing mechanism, embodying high speed, perfection of stitch, perfect tension control, yet simple and durable, and easily adapted to handle the most deli-

cate of fabrics, as well as the heaviest. The other machines of the type referred to also have points of excellence.

The type of machine used almost universally for finishing operations on knitted underwear is the one which makes some form of a chain stitch. The reason for its use is that the threads may be led to the machine and used directly from large cones or spools, thus avoiding the constant stopping of the machine to replace the empty bobbins with newly filled ones, as is the case with shuttle or lock-stitch machines. The item of interruption in a day's work is not inconsiderable.

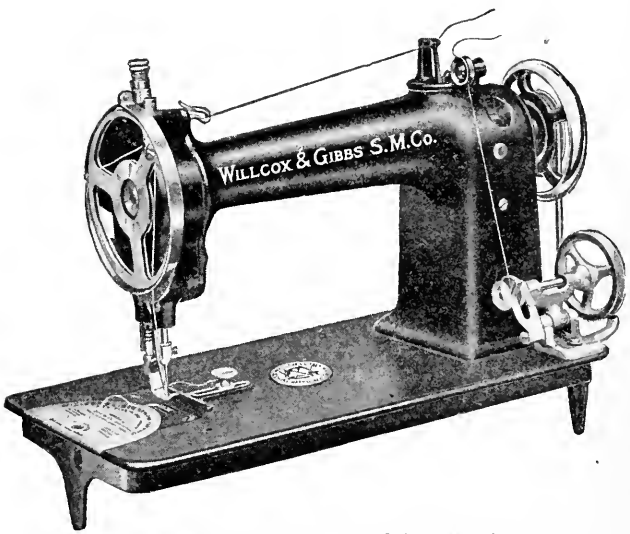


Fig. 24. Willcox & Gibbs Lock Stitch Machine.

The mechanical design and construction of the chain-stitch type, in the matter of continuous rotary motions, and strength and simplicity of parts, is more favorable to high speed than any lock-stitch type. For these reasons the chain-stitch machines are the most economical, both from the point of production, and care and expense of repairs. This stitch is also of advantage where an ornamental effect is desired, as on vest and drawer facings, or on the edge of binding.

The Union Special Finisher. The finishing machine designed and built by the Union Special Machine Company has found great favor for the latter class of work. They make either the two-thread

chain or "safe elastic stitch," or the single-thread chain stitch, and if so desired, the two types may be combined in one machine, for the basic functions of both are identical and the few necessary changes can be easily and quickly made. This point is of undoubted advantage in the case of a small mill where the number of machines is limited, or when there is not enough work to warrant the investment for separate machines for each individual operation. In a large mill, however, it is much more economical to make this provision, for by so doing a machine when once adjusted to a nicety for its particular

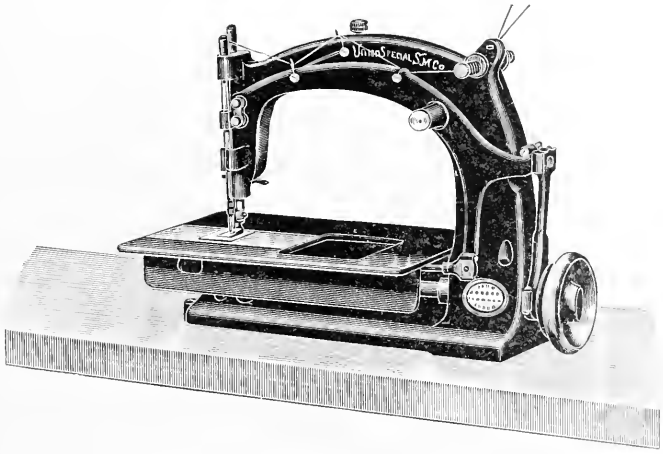


Fig. 25. Union Special Plain Finishing Machine.

work may be left so, and not require any further care from the adjuster.

One style of Union Special machine has been designed for finishing knit drawers. It is built on lines similar to those just noted, and has the same general characteristics. In stitching on an inside band, where a silk finish is desired, this machine makes a beautiful, ornamental stitch, greatly adding to the appearance of the garment. A large saving of silk is effected by using cotton thread in the needle, and silk, or a fitting substitute, in the looper, care being taken to adjust the tensions so that the upper, or cotton thread, will not show on the under side.

The Willcox & Gibbs Finisher. The Willcox & Gibbs chain-stitch finishing machines are largely used for binding, being especially adapted for the purpose. These machines are furnished with the automatic tension, or with the ordinary friction discs, a tight wheel, or the two tight and loose pulleys for driving, and a feed surface with one or two lines of teeth. They may also be had with the registering or measuring tension. The object of the latter is to measure off and deliver to the looper the exact amount of thread required for each stitch, to uniformly draw up each stitch to any desired degree of tightness, and produce sewing that is perfectly smooth and even without any care on the part of the operator. It can be readily adjusted, and the resulting seam will be of unvarying strength and elasticity. The thread cutter attached to this machine is worthy of note, because it prevents the characteristic tendency of this type of stitch to ravel. By its use the thread is cut at the end of every seam when the work is taken from the machine, leaving an end of thread about three-eighths of an inch on the under side and drawn through the last loop, which "fastens off" the seam and prevents its ravelling. It can be made doubly secure by pulling this end, which is through the last loop, toward the sewing. The cutting is accomplished by a slight forward and backward movement of the hand wheel by the operator when the needle is brought to a position to allow the work to be taken out.

The Singer Manufacturing Company build a single-thread, chain-stitch machine, having a similar method of forming the stitch, which has considerable room under the arm. It is similar in design to the machines of this type which have been described, differing in points of construction. The needle bar is driven by an upper rock shaft. This shaft lies back of the head-supporting arm, and its connection to the needle bar is completely covered in the head. Thus, no moving parts are here visible, and therefore are not liable to throw oil. The feed mechanism has positive movements, and the length of stitch is adjusted without the use of springs. This machine is furnished with the ordinary plain friction tension or an automatic device.

Adjustments and Repairs. All machines of the single-thread, chain-stitch type are capable of a limited variation in laying the stitch through the medium of their tensions. The thread may be drawn closely to the fabric, thus forming a close or tight seam, or it may be

left in an elastic chain as desired. A beautiful stitch, resembling braid may be produced by using coarse silk, which is effective as an ornamental finish on facings or bands. By manipulating the tensions in this manner, many pleasing results may be obtained with both the one-thread and the two-thread types of chain-stitch machines.

In making an ornamental edge on binding, it is customary to run the braid or binding through a machine directly from the roll, reeling it from a full roll on a pin in front of the machine to another one at the back. The operator who stitches this prepared binding to the garment will make the fold at the line of the ornamental stitching, thus presenting a silk purl on the edge.

All of the sewing machines which we have to deal with today have either spot screws or pins to confine the different parts in their proper functional relation with each other. This has been found to be absolutely necessary, and especially so with reference to high-speed machines; for even those built on the most scientific principles would become disarranged by a few turns at the rate of 2,500 or 3,000 revolutions a minute.

The location of these pins and spots on the shafts, studs, etc., is not determined until the most favorable relative positions of the several parts are fully established after many trials in the sewing-off or adjusting room; and when finally fixed upon these points of registration are exactly duplicated in every machine of the type in question by a set of accurate jigs and fixtures, many of them costing hundreds of dollars to design and build.

In timing the loopers of chain-stitch machines of the Willcox & Gibbs type, the eye of the needle should be about $\frac{1}{8}$ of an inch below the under side of the looper's hook, when the needle is at its lowest position. Then, as the needle starts upward and the looper point approaches it, these two implements should pass each other as closely as possible and not touch, with the needle's eye about one thirty-second of an inch below the under side of the looper's hook. This will ensure time enough for the needle to raise and throw out a good loop before the looper gets to it, and a good looper will then handle the thread during the succeeding stages of the stitch in a satisfactory manner.

In setting the needle, the long groove must be at the left, or away from the looper point, and its shank should rest against the bottom

of the hole in the needle bar. If the eye of the needle is then not at its proper height in relation to the looper, as described above, it can be adjusted by the eccentric ball at the driven end of the needle-bar lever. In some of these machines it is possible to turn the needle in the bar, or the bar itself, which is an advantage when it is desired to throw the loop to or from the looper's point, thereby favoring the latter a trifle in handling different qualities of thread. Generally, however, the loop should throw out squarely with the line of feed.

The looper is positioned in its rotary direction by a spot on its shank which receives a set screw in the shaft, and the only adjustment which is usually necessary for this implement is in its endwise position, to bring it to or from the needle. If it seems desirable to time the looper a trifle quicker or slower, this may be accomplished by changing the spot on its shank one way or the other with a fine file.

When the needle and looper in this type machine are in their proper relation to each other, it will be found that the tension, once adjusted, will need but very little variation. Care must be taken, however, that it is not so tight as to destroy the elasticity of the stitch's varying thicknesses of material or a change of stitch to fine or coarse, may require a slight alteration of the tension.

In timing the looper of the Union Special two-thread, chain-stitch machine, the eye of the needle, when in its lowest position, should be about three-sixteenths of an inch below the under side of the looper. The shank of the needle should rest against the bottom of the hole in the needle-bar, with the long groove in front or towards the operator, and securely fastened. If the eye is not at the proper height the bar can be raised or lowered in its driving connection. Care should be taken to use needles that are perfectly straight and have good points. The size of needle is determined by the thread used, a fine thread taking a small needle, and so on. Many times when a machine is working poorly, a larger size needle will handle the thread better and eliminate all the trouble.

The looper should be adjusted so that its point is one fourth of an inch from the needle when it is at its extreme throw to the right, and, in passing the needle on the back side, that the point will just clear the needle. This will ensure a good loop when the looper has advanced to meet it. When the looper makes its return throw to the

right, the needle must pass the back side of the looper with its point a little to the right of the looper's eye, in order to take and hold this looper-thread until the next needle-loop is secured by the looper, thereby locking or enchaining the previous stitch with the last one. In passing each other, the needle and looper should just clear on both strokes.

These adjustments of the needle and looper may be varied a little to meet varying qualities of thread or material, but for ordinary conditions they are correct. Enough tension should be used on both threads to produce an even stitch, but if an elastic stitch is required the under tension should be considerably lighter than the upper. If either one fails to control the thread properly it may be found that a bit of lint has collected between the discs, thus holding them away from an even contact with the thread.

When the under thread lies straight from the heel of the looper to the double-wire fork, and just before the approaching edges of the rotary take-up touch it, the nipper-spring should hold the thread fairly tight, for at this point in each revolution of the machine the required amount of under-thread for the stitch is determined. If it is desired to regulate this, it may be done by means of the set screw in the lug on the looper-rocker, the head of which rests against the free end of the under nipper-spring, and taking its motion from the looper-rocker, serves to open and close the two nipper-springs in contact with each other. As the take-up revolves it will carry the thread upward and back, so that the retaining wire will catch and hold it until the slightly lower part of the take-up is in a position to allow the cast-off to take place.

The duties which are required of a feed and presser-foot in this work are identical in all machines, so our treatment of these two functions will apply to both of the types under consideration.

The top of the feed must be level and the teeth fairly sharp, but with no "hooks" or "burrs" on them. If the feed points seem to be too sharp, or cling to the fabric, a good remedy is to hold them against a revolving wire brush, just enough to smooth the points and not dull them materially. The rise of the feed surface above that of the cloth plate will vary within certain limits, according to the weight and texture of the material to be sewed, but for general work this should be about 1-32 of an inch.

A *hinged presser-foot* is the best for nearly all classes of work, for it enables the seams of garments to pass between the feed and foot more surely, and will conform to the top of the feed in any position, thus ensuring a firm hold on the material from a minimum amount of tension on the presser-bar spring. In the operation of binding it will be found that the feed and presser-foot must be in good condition, and in correct relation to each other. The presser-foot must set squarely on the feed points, with no side motion, and have an even contact on the cloth plate when the feed has dropped for its return stroke. If the goods have a tendency to run off sideways, in feeding through, it will probably be found that some one or more of the feed or presser-foot conditions are not right.

General Adjustments. In the course of time, with all machines, it becomes necessary to give them something more than a somewhat superficial "setting in order," and a general overhauling is required. When one shows signs of excessive wear, a few new parts, and a general tightening up of joints and fits will restore the machine to a more efficient condition. An adjuster who watches his machine closely will detect the wearing points about them as they begin to appear, and by judicious attention here and there can postpone the time when a general overhauling will be necessary.

The parts of all machines worthy of mention are manufactured in duplicate, so that a new part will replace one that has worn out without any fitting. New parts may be ordered from a catalogue of parts pertaining to the machine in question.

Many of the wearing parts are provided with means for taking up this wear as it occurs, but in the case of shafts and needle-bars this is not so, and when these parts become badly worn the only remedy is to replace them with new ones a trifle larger, and ream the holes to fit. For this purpose the shafts and bars are made in two or three different sizes, one being three or four thousandths of an inch larger than the original, and a third the same amount larger than the second one, thus providing for several renewals.

The holes are enlarged by an expansion reamer, having a long pilot extending from both ends of the fluted cutting section. In using this tool care should be taken to ream the holes perfectly straight, and a very little at a time, in order to secure as good a fit as possible and keep the bearings in true alignment.

The Union Special Company has introduced a new method of mounting the needle-bar, which provides for a renewal of the worn-out bearings, as well as the bar, and also furnishes means to take up a limited amount of the wear before a renewal is absolutely necessary. In the construction of these bearings the two ears, or lugs, through which the needle-bar passes, are drilled and reamed out at the factory somewhat larger than the bar itself, and a thin shell, or bushing, is inserted, which is then the bearing. This bushing, and also the encircling lugs, are split on one side, and by means of clamping-screws in the latter, the bushings may be collapsed a sufficient amount to meet the reduced surface of the bar. In case of renewal, these bushings may be discarded and new ones inserted to fit an original-sized bar, or they may be retained and re-reamed for the next larger one, as in the older method. The great advantage of the new system seems to be the clamping feature, which allows the wear to be followed up as fast as it occurs.

MISCELLANEOUS MACHINES USED IN FINISHING KNITTED UNDERWEAR

There are various operations in the finishing of knitted underwear that are performed differently, and with different machines, according to the system or custom in force in the mills. Some mills use for binding what is called a purl edge binding, made in the mill by running plain binding of most any kind through a Union Special Single Needle Ornamental Machine, oftentimes called Binding Machine. This machine is built on the same lines as their drawer finisher with certain minor changes, and with attachments for holding and guiding so that the purl edge may be laid on in the middle of the binding as it passes through the machine. Oftentimes the machinist in the mill is ingenious enough to rig up an attachment for rolling up the binding as it comes from the machine.

One of these machines arranged in the above manner, will, after being started, make the purl edge on the whole roll of binding without attention of an operator until a new roll is to be started.

As drawer bands have to be stitched together, most mills have in their outfit a band stitcher. Any extra machine can be pressed into service for this purpose, though it is preferable to have a two-thread machine; it is often a W. & G. plain tension machine as anything else, and even sometimes an old line lock stitch machine.

A drawer strapping machine is important now, as many manufacturers are sewing on suspender straps in a durable manner with machines especially designed for that particular purpose. While straps have been sewed on with plain single, and double thread, chain, and lock stitch machines, it has always been apparent that a zigzag lock stitch was the most desirable. The "Standard" have a machine for such a purpose, the Union Button Sewing Machine Company and the "Singer" have a machine especially designed and adapted for sewing suspender straps on drawers and making stays and bars at required places in union suits and ladies' vests. It fastens the strap securely, rapidly and in a proper manner.

Zigzag machines have been used for several purposes after being adapted more or less to the work required such as sewing in gussets of drawers, such a stitch covering the raw edge nicely, besides sewing it on securely. They are sometimes used for covering the edge of the cloth left raw after running the necks. Sometimes a zigzag stitch is used with good effect on the facings of garments, or for making bars at intersections or parting of the seams on drawers, union suits, etc.

For covering the raw edge after running the neck, the Union Special Twin-Needle Machine makes a pretty ornamental stitch, as well as effectually covering it. It has two needles and one looper, leaving two parallel lines of stitching on the back and an interwoven fancy stitch over the raw edge of either silk, worsted or cotton thread, as preferred. It is the same stitch as made by the cylinder side-wheel covering machine, though the twin-needle machine, so called, for necking, is a regular flat machine. It is also sometimes used for catstitching, or wherever a pretty ornamental stitch is desired. Often it is called a Necking machine.

Twin-needle and *two-line machines* are often confounded. Two-line machines make two separate rows of stitching on both back and front of work, and require two needles, two loopers or hooks, and use four threads. Two-needle machines are by no means always two-line machines. For instance, the so-called twin-needle or necking machine, has two needles, but only one looper, and consequently runs but three threads. The side wheel covering machine is similar as to needles, looper and number of threads. In fact, the covering machine is simply the twin-needle machine redesigned in the form of a cylinder machine to facilitate the handling of the work.

Two-line machines are used wherever it is desired to have a double row of stitching, as on the outside of drawer band—covering the back seam of drawers with tape—sewing on each side of the tape simultaneously, being fitted with a device for holding and guiding the tape properly. It is commonly called a Taping Machine. Wherever two-row work is required, two-line machines are desirable, because the lines of stitching are more likely to be parallel, more sightly, and the work turned off much quicker. Two-line machines are built almost any width between the rows, from 3-32 to 13-32 of an inch. Special widths are made from 13-32 to 21-32 of an inch.

End sewing machines were formerly required, but where covered seams are made, and covered seams are almost universal, none are necessary. Almost any zigzag machine answers the purpose where such a machine is required, though there is a machine made especially for this purpose.

Hemming machines are used for shirts or vests, on flat goods, or rib-tails, either looped or stitched on, take the place of the hem. On ribbed goods, the hem is made on a machine designed for the purpose, the "concealed" stitch being much in favor, though edging machines are used for this finish in many instances.

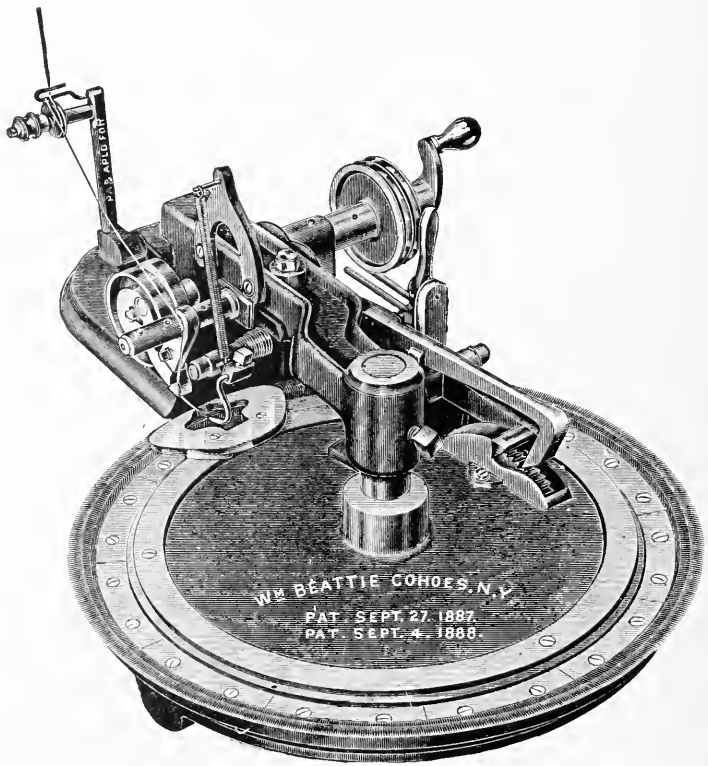
THE LOOPING OR TURNING-OFF MACHINE

Within the province of sewing processes for elastic knitted fabrics, and the various more or less complex mechanisms with which they are severally executed, comes one which, in its final appearance, has the most satisfactory effect of all, from many standpoints. Yet, strange to say, its accomplishment is by means of a type of mechanism that is wholly at variance with all of the latter-day ideas which the modern sewing machine calls for. We refer to the familiar process of looping one piece of material to another, and as is well known, the finished product is nearest to perfection of anything in the art of joining two parts of a knitted garment.

The beautiful flat effect which is obtained by this peculiar method, and the effectual merging of the sewing thread with those of the fabric itself are features which have effectually combined to continue this abnormally slow process in use at the present time.

This looping machine—variously called *looper*, *turning-off machine*, or *ribber*—is extremely simple in construction, containing as

it does only the principal fundamental sewing-machine functions, and it has passed through but few radical changes since its inception years ago. Indeed, it requires no stretch of the imagination to recognize in its main features those of the orginal Elias Howe hoop wheel feed model for a sewing machine. Even so, it is today the only practical device which will do its work perfectly, owing to the prime necessity of first impaling each individual knitted loop of both parts of the fabric



Fig, 26. Beattie's Looper or Turning-Off Machine.

to be united on a separate point or needle. It is from this peculiar fact that it is possible to cut, ravel, or trim, all surplus stock away from these loops before proceeding with the operation of sewing, thus producing in the opened-out joint, or seam, a result so perfect that the two parts thus joined will appear as one integral piece. Indeed, most people who wear such underwear think it is "knit that way," not knowing that the cloth comprising the body of a garment is knitted

on a circular machine, making a wale on one side only, and the firm but very elastic rib or cuff is knit on what is termed a *rib* machine. (Hence the term ribber previously mentioned as applied to one machine for joining these two parts together.) The rib-knitting machine is built on an entirely different plan from the circular one in that it has two sets of needles, and produces wales on both sides of the fabric.

In the rib machine, also, its needles are manipulated in and out of the yarn loops successively, as the fabric progresses in groups, which vary in number according to the desired width of rib or cuff being made, and as its motions are intermittent, the process of making this part of a garment is necessarily slow.

In the circular knitting machine the process is, as its name implies, circular and therefore continuous.

While the looper, or turning-off machine, is one where the operator works constantly, it is also working constantly itself, if speeded to the operator's gait. To the uninitiated, looking at the operator sitting on a low seat, putting the toes of a stocking, or the parts of the fabric to be looped, on the points of the dise of the machine, stitch by stitch, one loop on each point, it may seem easy, but it is soon apparent that quick and strong sight and nimble fingers are required, and also that the machine is capable of running much faster than the most expert operator can place the loops on the points in the proper manner to obtain perfect work.

Other Methods of Joining the Rib. From time to time devices and machines have been brought out that were designed as substitutes for, and to hasten this exceedingly slow process. Some of them have met with a fair amount of success for a time on certain classes of work, but none were acceptable on the finest grades of this fabric, so we still have the looping machine in almost its original form of forty years ago.

Of all substitute methods and machines for this purpose, perhaps the most satisfactory has been the one of utilizing the "Overlock" stitch. This consists of placing a row of these stitches along the edge of each part of the fabric, to be joined in such a manner that their loops form two continuous selvedges, and a subsequent operation will join them. This method is much quicker, stronger, and produces the desired flat seam.

Other devices have been the so-called pin-wheel sewing machines of different types. In this plan the familiar wheel of points to hold and carry the fabric to the needle was retained, but the necessity of impaling each knitted loop on a separate point was eliminated by providing an exceedingly fine feed, with the result that while some of the uniting stitches would be made between the wales of the fabric, each knitted loop would receive at least one. This method proved to be a great time saver, but lacked the finished appearance of the genuine looping method, and it is not now used to any great extent.

Looper Trimmers. For the purpose of assisting the operator in her work, and to reduce the amount of time necessary for this operation of looping, various automatic devices have been introduced, whose office is to remove the surplus material projecting above the feed-wheel points, and prepare the impaled loops of fabric for the final sewing operation. This had previously been required of the operator herself, and while it did not take a great deal of her time, an expert being able to cut and brush away the ravelings very quickly, these attachments did show a percentage of saving by allowing the operator to devote her whole time to impaling the loops of the fabric on the looper points.

These attachments operate in various ways, the most practical embodying a combination of the cutting and brushing processes. They have been arranged for use on both the old-style looper and several of the substitute pin-wheel machines.

Straight-Bed and Circular Loopers. For convenience in handling the various classes of undergarments during the looping process, looping machines are made in two forms. One with a straight bed on which a row of work-holding points are mounted to project along one of its sides, and having the stitch-making group of parts assembled on a traveling carriage. This form of machine holds the work stationary while the needle-looper, etc., are automatically moved along the bed from point to point after each stitch is completed.

The other form of machine is a circular one, in which the work-holding points are mounted to project from the periphery of a disc about eighteen inches in diameter. In operation this disc is given an automatic rotary feeding motion on its axis after the completion of each stitch. Thus it will be seen that the operating functions of the process in the two forms of machine are exactly in reversed order,

one holding the work in position, while the stitches are inserted progressively along the prepared edge of the material, and the other proceeding reversely to carry the prepared edge to, and by a stationary group of stitch-forming implements. The first, or straight-bed form is more peculiarly adapted for use on what is called "full-fashioned" garments, and the circular form is most generally used for "cut goods."

Character of the Stitch. In both forms of machine the stitching functions are practically alike, and produce the same finished result. By different arrangements of these parts in their relation to each other, and to the automatic feed, as to time, etc., several styles of stitch may be obtained, such as the "single stitch," "under and over," and "through and through" or "double stitch," and may use one or two threads, each style of stitch having its peculiar advantage for the work in hand. In some makes of machine the needle,(always a curved one), works from the inside or butt end of the points, outward, and others work in the reverse direction.

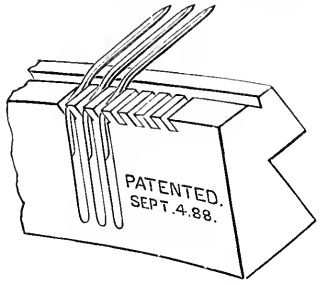


Fig. 37. Looper Points.

Operation. In setting up the circular looping or "turning-off" machine, it must be fastened securely to a good table, similar in construction to the ones used for sewing machines. It need not be as wide, however, as it is never required for holding the work during this operation, and also because the full diameter of the disc, and several inches more must overhang the table's edge so as to be sure and provide ample space for the work to revolve while depending from the feed points.

The two pieces to be sewed together or looped are fastened to the disc, so that one of the points shall pass through each of two courses of loops near the raw edges of the fabrics, which are in position with their faces together.

The rotation of this disc will then bring each pair of loops in succession to a point of exact registration with the needle, which travels in the arc of a circle directly over and parallel with each point when in this position. A groove or depression in the top of the points will allow the thread-carrying needle to enter each pair of loops, and

in conjunction with a properly shaped looper, which operates in time to meet the needle's thread, the two fabric loops are securely and almost imperceptibly joined.

In order that the machine may operate successfully and perfectly, it is necessary to trim the raw edges of material down to the loops that are impaled upon the points. Unless this is done and all the raveled threads and loose waste be removed before passing under the needle, the seam will be made with an unsightly welt.

The speed of the machine is limited to the ability of the operator in putting the loops of fabric on the points, and with those who are most expert it can never be run more than 300 or 400 stitches per minute.

Adjustments. If the machine skips stitches, examine the needle. If broken or damaged beyond repair, replace with a new one. If the point is dull make it over with an oil stone, care being taken to have the lower side as low as possible, so as to ensure its entering the loop. See that the point of the needle registers exactly over the center of each point. Skipping is also often due to the hook or looper getting out of adjustment. When taking the looper from the needle, the looper must slightly rub the needle when passing over it. The needle may move too quickly or too slowly and thus be out ot time with the looper. When properly timed, the needle's point in entering the loop on the hook should be one-sixteenth of an inch from the hook, and just clear the heel of the looper, The hook, after passing away from the needle, will again move forward and pass under the needle, just touching it. The hook will be about one-eighth of an inch from the point brass when it is at its lowest drop. It is very essential to have the hook perfectly smooth and of such a shape as to keep the loop of thread from dropping off, and also to allow it to slip off easily before the needle enters the new loop. Keep the thread taut during the time the needle is passing through the loop. Have the thread rather too fine than too coarse for the needle.

In order to replace a point, remove the brass section that covers the base of the imperfect one, and remove it with a quick pull upward, thus preparing the groove for the new point. Place the new point in position, and with a small staking tool drive it to its seat, then with a hammer smooth the brass down around it, and finally replace and secure the covering brass in position.

The sewing mechanism must be timed with the points on the large disc, and if not exactly right their relative position may be changed by loosening the set screws in the main arm of the machine, and moving the disc to its proper position.

NAPPING KNIT GOODS

Brushing. Brushing is generally done in a machine similar to the one shown in Fig. 28. Many grades of goods are thus made to present a much more sightly and saleable appearance by being run through the garment brushing machine which raises the stock a

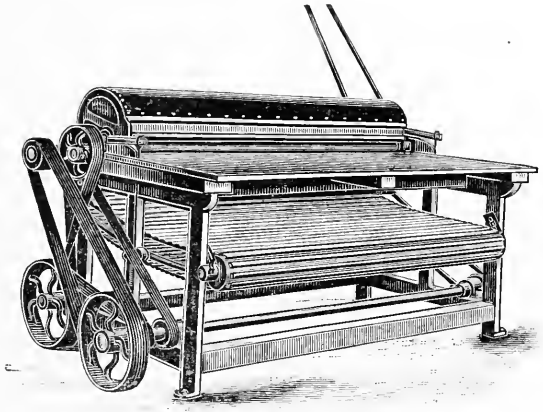


Fig. 28. Garment Brushing Machine.

little and gives the garment a soft and lofty feel and a more wooly appearance. It is customary to brush only the outside of the garment, but in some instances it seems desirable, for selling purposes, to brush both outside and inside, and in other instances it is run through the brusher twice to get more of the woolly appearance. These machines are not intended to tear up a nap like napping machines do, the rolls being made with stout, stiff bristles—instead of wire card clothing—that raises a light nap which has a tendency to give cotton or mixed goods more the appearance of wool. The process and the machine are shown in the illustration, and the samples of cloth shown indicate or illustrate the difference in appearance before and after brushing, the wale of the cloth being almost covered up by the nap after brushing.

Napping. A thread is tied into the fabric when it is being knitted, for the express purpose of making the nap, but it does not really form a part of the fabric. On goods where the nap is worked out of the fabric, without this backing thread looped in, it really destroys much of the strength and durability of the fabric, hence the introduction of the backing thread.

The great objection to napping on underwear is the tendency of the small fibers to roll up into lumps, and to become detached from the fabric in use, or to accumulate into hard lumps in washing. A close felted nap does not exhibit this tendency in so great a degree as one that is long and combed out.

The first nappers used on underwear made the nap by brushing with a rapidly revolving cylinder covered with a comparatively long straight tooth clothing which had a tendency to cut the loops and drag out the fibers into a long, hairlike fleece. This was objectionable on account of the amount of flocks detached from the fabric and the tendency of the nap to roll up or "pill," and led to the use of the teasle gig, similar to those for finishing woven fabrics. This gradually worked out a shorter, felt-like nap, but was too slow and expensive, and the teasles were superseded by wire clothed gig nappers. These are of two kinds, *single acting gigs* and *double acting gigs.*

The single acting gig has a number of rolls journaled in a revolving cylinder and covered with wire clothing, all the points being bent in one direction. Means are provided for turning the rolls on their axes independent of the movement of the gig. This was an advantage over the brusher but is no longer used for underwear, as the double acting machine is better.

The double acting machine has the gig rolls in pairs, and a separate motion is provided for controlling each set so that they can be driven at different speeds, or, as compared with each other, in different directions.

The clothing also is of different shape, usually being straight or with a very slight pitch on one set of rolls and having a knee or sharp bend forward on the other set. The straight tooth or "carrier" rolls handle the cloth and hold it against the action of the bent tooth or "worker" rolls. They also help to release the fabric from the workers. The workers seem to dig into the fabric a certain distance when

the action of the carriers release their hold on the fabric and by repeating this movement rapidly work out the fibers of the yarns composing the fabric, into a short heavy nap.

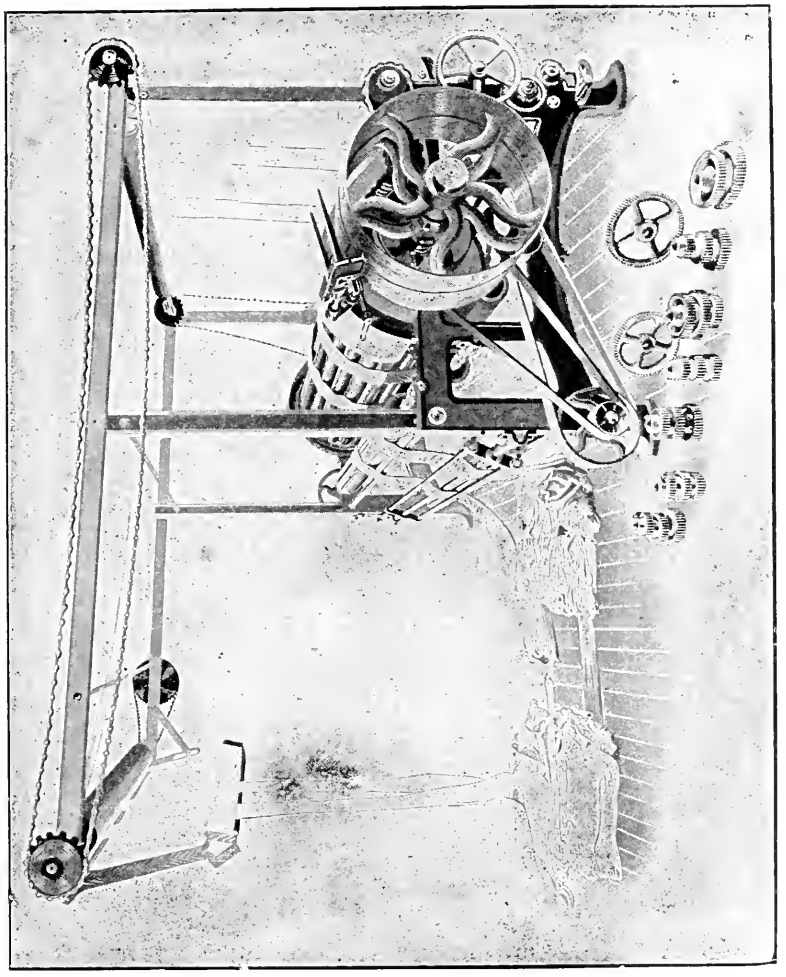


Fig. 29. Stafford & Holt Napping Machine.

On the Stafford & Holt Napping Machine, of which Fig. 29 is a view of the driving end, the gig runs contra-clockwise, or the top of the gig runs over toward the side where the cloth is fed in. The rolls in the gig turn in the opposite direction, that is, in a direction that will carry the cloth through the machine. The bent tooth rolls

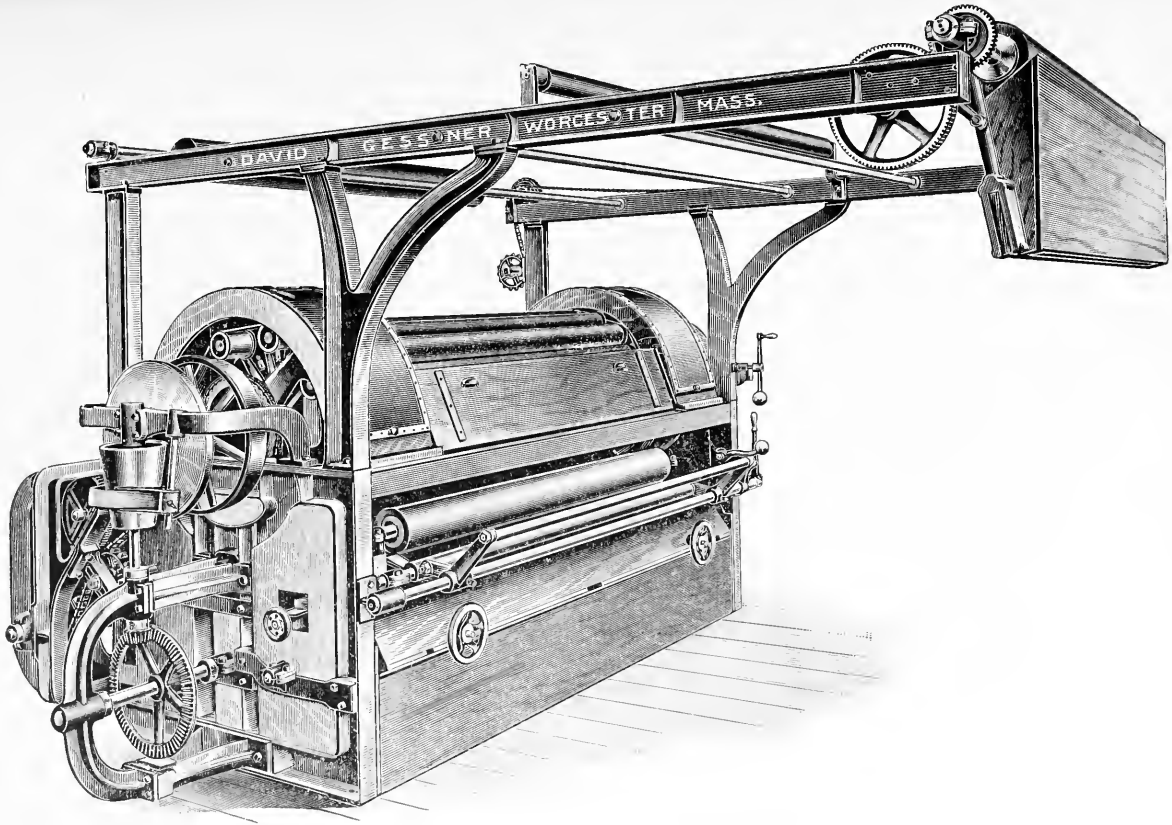
are governed by a large internal gear on the driving end of the machine and the straight tooth rolls are governed by the internal gear on the opposite end of the gig. The function of the straight tooth rolls is to hold the cloth while the bent tooth rolls act upon it. They should be given enough speed to keep the cloth just slightly strained around the gig. A large change gear on the feed shaft loosens the cloth and a smaller one tightens it.

With a 96-tooth gear on the sprocket stud it would require from a 48 to a 56-tooth gear on shaft. The napping is done principally by the bent tooth "worker." With a 110-tooth gear on the sprocket stud, and a compound intermediate of 52 and 26 it would require from a 50 to a 21 pinion on the shaft for napping. The smaller the pinion the harder it will nap, say 38 into 52 and 26 into 110, the 52-26 being the compound intermediate, to be varied as required for the different fabrics and the character of the nap.

Napping "flat" goods, "straight-ribbed" goods and "jersey-ribbed" goods (or "fleece backs" and "plush backs") is better accomplished on *planetary* nappers, because they make a much shorter, thicker, and more evenly distributed nap than regular nappers, and give a more velvety feel. The nap obtained by this means is much less matted into knots or bunches by rubbing or washing, and the fabric handles much thicker and fuller, even after washing and use.

Planetary nappers contain, principally, a napping drum, a cloth feed roll, a series of napping-rolls mounted upon the drum and containing points inclined in the direction in which they act upon the cloth; crimper-rolls containing practically straight points mounted upon the napping drum and interposed in the series of napping-rolls, and a tension roll arranged to act on the cloth in advance of the napping action. The plurality of series of nap-treating members are mounted upon the drum, so arranged that a differential action is produced between the members of one series and the members of another series. The result of this action on the cloth is somewhat analogous to felting, inasmuch as the napper rolls raise the nap, and the other series of rolls serve to bend or crimp the fibers and drive them in making a felt or "fleece."

The mechanical construction of the David Gessner napper is described and illustrated to make the operation clear and comprehensive.



GESSNER KNIT GOODS NAPPING MACHINE

David Gessner

Referring to Figs. 30, 31, 32, and 33. The frame is composed of the upright end pieces 1 1′, connected at the bottom by the girders

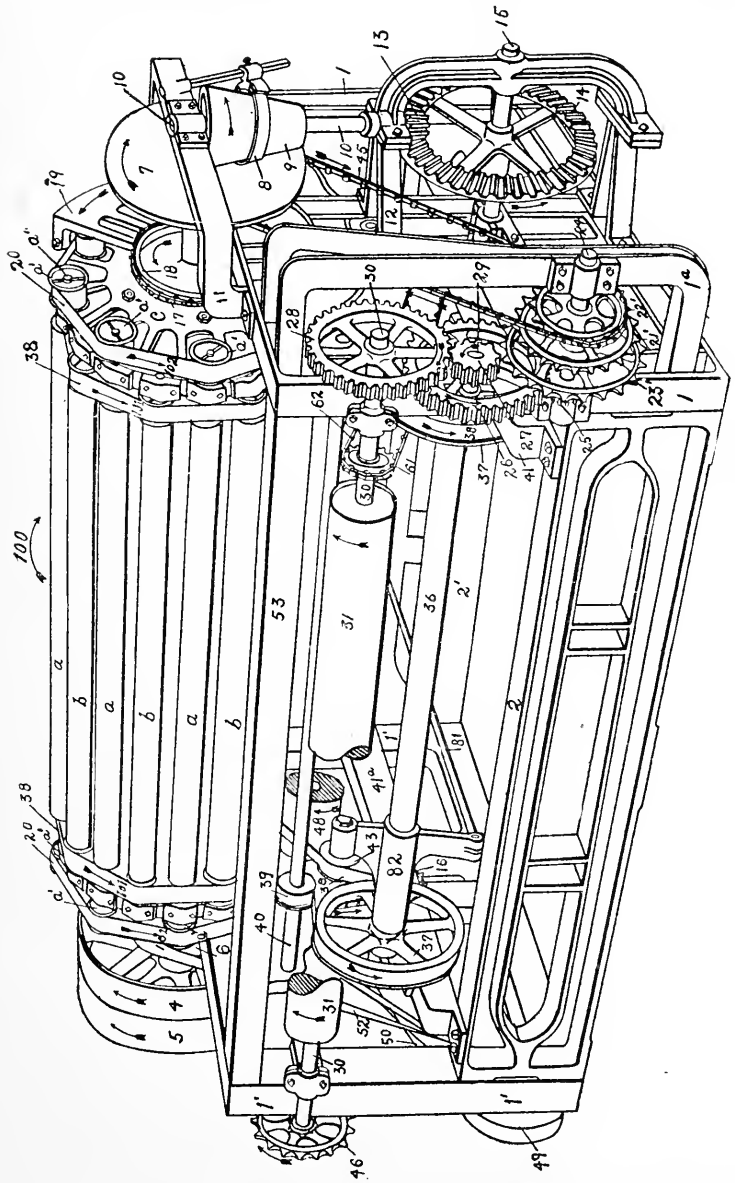


Fig. 30. View of David Gessner Napper.

2 2′, which are united again crosswise by brackets or stays 41 and 41ª, and at the top by the girders 53 and 53′ and carries upward

extensions 1^b 1^c and horizontal member 1^d, and a yoke on the side, marked 1^a.

Number 3 is the main shaft, carrying the heads *c c*, on the outer periphery of which are mounted the napping-rolls *a* and the contact-rollers *b*, which are called "crimper-rolls," because their contact against the ends of the napped fibers serves to bend or crimp the fibers with a result which is analogous to felting.

Number 4 is the fast pulley, by which the main shaft is driven, and 5 is the loose pulley. 6 is a pulley, fast on the main shaft, from which by the belt 52 is driven a pulley 52^a, fast on the inside of pulley 49, from which the shaft 47 is driven through the belt 50 and pulley 51. The stripper roll or fancy, 48 is fast on the shaft 47.

The napping-rolls a are covered with card clothing, the points of which are inclined in the direction in which they act upon the cloth. The crimper-rolls *b* are covered with card clothing having straight or radial points. The napping rolls, at their points of contact with the cloth, move in non-unison with the cloth, so that their points raise the nap. The two series of rolls act differentially, the napping series serving, as it were, to comb out the nap and the crimper series serving to crimp or felt the nap.

The mechanism for driving the napper-rolls a consists of the disc 7, fast to the main shaft 3, the belt 8 and the conical roller 9 co-operating with the disk, the shaft 10, upon which the conical roller is mounted, having its bearings in the brackets 11 and 12 and carrying at its lower end the pinion 13, which drives the gear 14, fast upon the counter-shaft 15. Upon this counter-shaft are fixed, on the inside of the frame, sprocket-wheels 16, 16, (there being one for each end of the machine) from which, through the sprocket-chains 17, are driven the sprocket-wheels 18, 18, (there being one at each end of the napping-cylinder), fast to the spiders 19, which carry the belt 20, which passes around the series of pulleys *a'*, *a'* on the ends of the shafts a^2 of the workers *a*. By raising or lowering the belt 8 any desired speed may be given to the workers *a* for increasing or decreasing their napping capacity independent of the speed at which the cloth may be running, and independent of the speed at which the travelers *b* may be running, and independent also of the speed at which the main shaft is running.

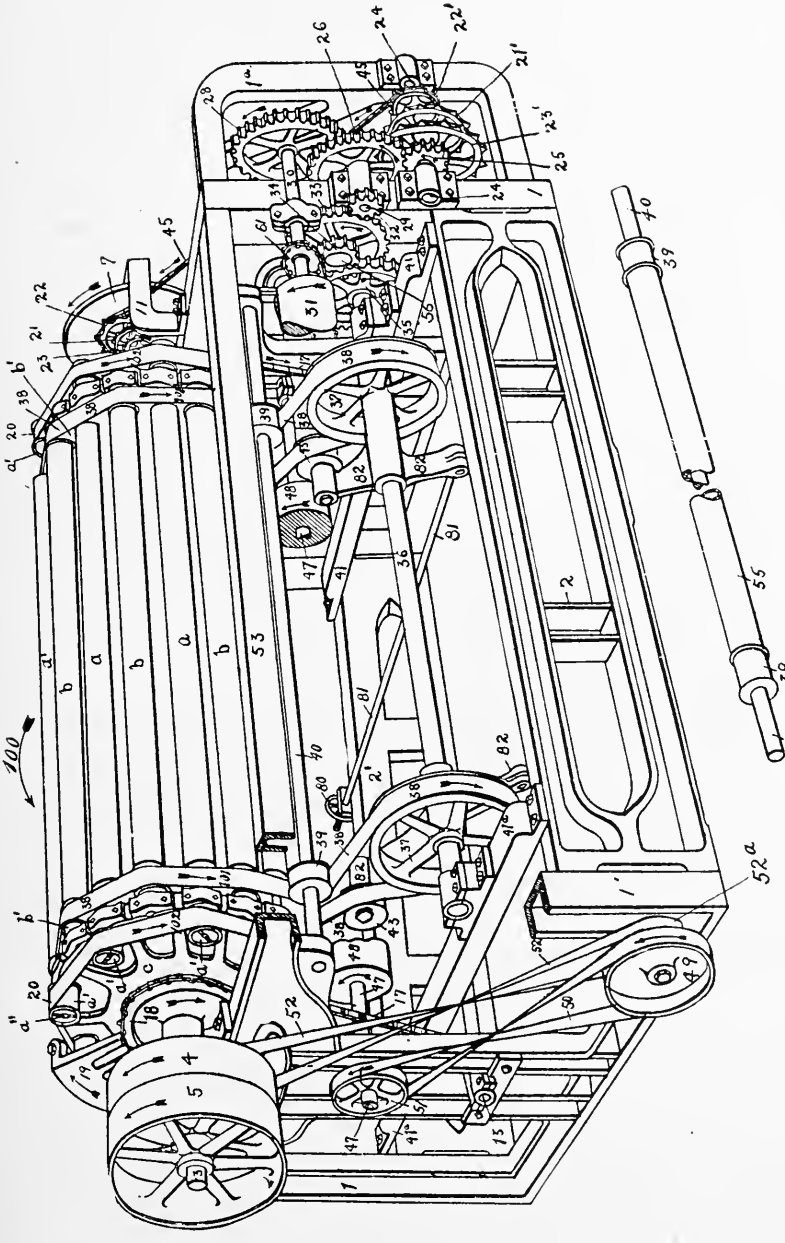


Fig. 31. View of David Gessner Napper.

The mechanism for driving the cloth-feed rolls, of which 31 is one, is as follows: 21, 22 and 23 are sprocket-wheels fast to the main shaft. 21′, 22′, and 23′ are corresponding sprocket-wheels fast to the

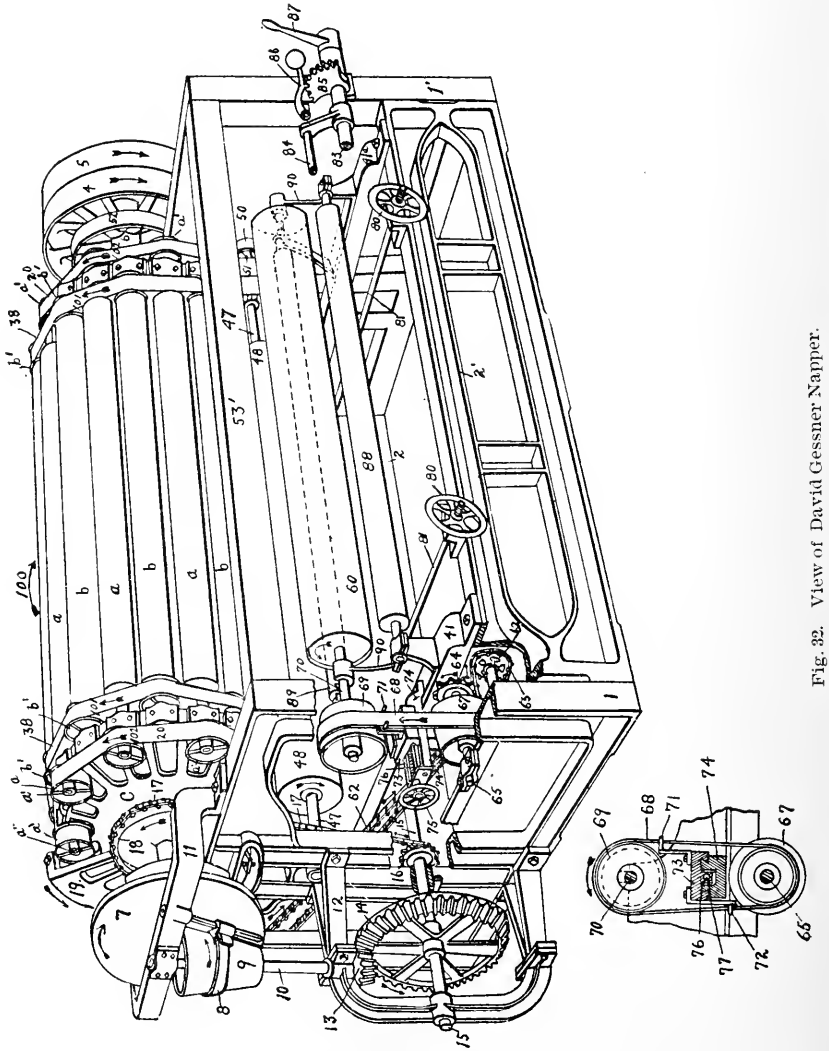


Fig. 32. View of David Gessner Napper.

counter-shaft 24. 45 is the sprocket-chain, by shifting which from one pair of said sprocket-wheels to another the speed of the counter-shaft 24 may be varied with respect to the speed of the napping-cylinder. 25 is a pinion fast on the shaft 24 and which drives a gear

26, fast on the shaft 29. The pinion 27 is fast to the gear 26 and drives the gear 28, fast on the shaft 30, to which shaft the cloth feed roll 31 is fast. On the opposite end of the shaft 30 is fixed the sprocket 46, from which may be driven all other cloth feed rolls in the machine.

The entrance tension-roll 60 is driven as follows: On the shaft 30 of the rear draft-roll 31 is fast a sprocket-wheel 61, which drives a chain 62, which drives a sprocket 64, fast on a shaft 65, carrying a cone 67, which drives a belt 68, which drives cone 69, fast on shaft 70 of the entrance tension roll 60. The chain-idler 63 serves as a take-up for chain 62. By shifting the belt 68 on the cones 67 and 69, the speed of the entrance tension-roll 60 may be varied at will relatively to the speed of the other feed-rolls and traveler-rolls. This adjustment is a feature of the utmost importance, because it vastly increases the scope of the machine with respect to the range of materials which may be successfully treated by the workers *a*. For the purpose of enabling this adjustment to be made while the machine is running, and to be regulated to a nicety, the following mechanism is provided, whereby the operator may shift the belt 68. 71 and 72 are belt-forks fastened to the carriage 73, which is made to slide upon ways on the bracket 74, fast to bracket 41. By a screw-spindle 76, with hand wheel 75, nut 77, fast to carriage 73, is moved so as to shift said forks and belt 68 at will by the operator while the machine is running.

By the adjustment last described the tension of the fabric being treated can be regulated to suit very tender fabrics, which by too great a tension are liable to be torn or stretched and narrowed, and by too little tension are liable to be dragged forward by the workers *a*, and thus slacked up in a manner causing disaster.

The mechanism for driving the crimper-rolls b is as follows: Upon the opposite end of the shaft 29 from the gear 26 is fixed a pinion 32, which drives a gear 33, turning upon a stud 56. The gear 34 is fastened to the gear 33 and drives gear 35, fixed on the shaft 36, having its bearings upon stays or brackets 41 and 41ª. The pulleys 37, 37, are fixed on the shaft 36 and drive the belts 38, 38, which extend around the pulleys *b* at opposite ends of the crimper-rolls *b*. These belts 38, 38, run under the idlers 39, 39, and over the idlers 43, 43, respectively, so as to substantially encircle all of the travelers *b*. Whenever the chain 45 is shifted from one pair of sprocket-wheels to another for the purpose of varying the speed of

the cloth relatively to the speed of the main shaft, a corresponding variation will be produced in the speed of the belts 38, 38. Therefore any change in the speed of the cloth feed rolls, as 31, will be accompanied by a corresponding change in the speed of the crimper rolls *b*.

In the particular form of this machine the mechanism above described is so proportioned that the surface speed of the cloth feed rolls, as 31, is substantially the same as the surface speed of the crimper rolls *b*, which surface speed of the crimper rolls *b* is the resultant between the speed of the crimper rolls *b* upon their own axes and the speed at which they are carried bodily by the cylinder-heads *c*. In other words, if the diameter of each pulley *b'* is the same as the diameter of their respective crimper rolls *b* the belts 38, 38, may have substantially the same speed as that at which the cloth being treated is traveling through the machine.

The relationship between the speed of the crimper rolls and of the feed is maintained constant in the operation of the machine notwithstanding and independently of any variation which may be made in the speed of the working rollers *a* or of the main shaft. The shaft 29 constitutes a common actuator for the cloth feed rolls and the crimper rolls. The connections between this common actuator 29 and the cloth feed rolls, as 31, are invariable. Likewise the connections between this common actuator 29 and the crimper-rolls *b* are invariable, so that for a given speed of this common actuator a corresponding speed will be communicated both to the crimper rolls and the cloth feed rolls, and the speed of one will be invariable with respect to the speed of the other. In the connections, however, by which the common actuator is driven the shifting of the sprocket-chain 45 affords a speed adjustment whereby the speed of the common actuator 29 may be varied with respect to the speed of the other parts of the machine.

The belt 38 can be taken up and tightened by turning the hand-wheels 80, which are screw-threaded to the rods 81, that engage, respectively, with the swing-arms 82, which are loosely mounted on shaft 36 and carry on their free ends the idlers 43.

The broken line *d* indicates the cloth being treated. In leaving the napping-rolls it passes under a roll 55, fast to the two idlers 39, 39, and turned with them at the same surface speed as the surface speed

of the crimper rolls *b* by the power of belts 38, 38. Thence it passes under and partly around the feed-roll 31, under the weighted roll 54,

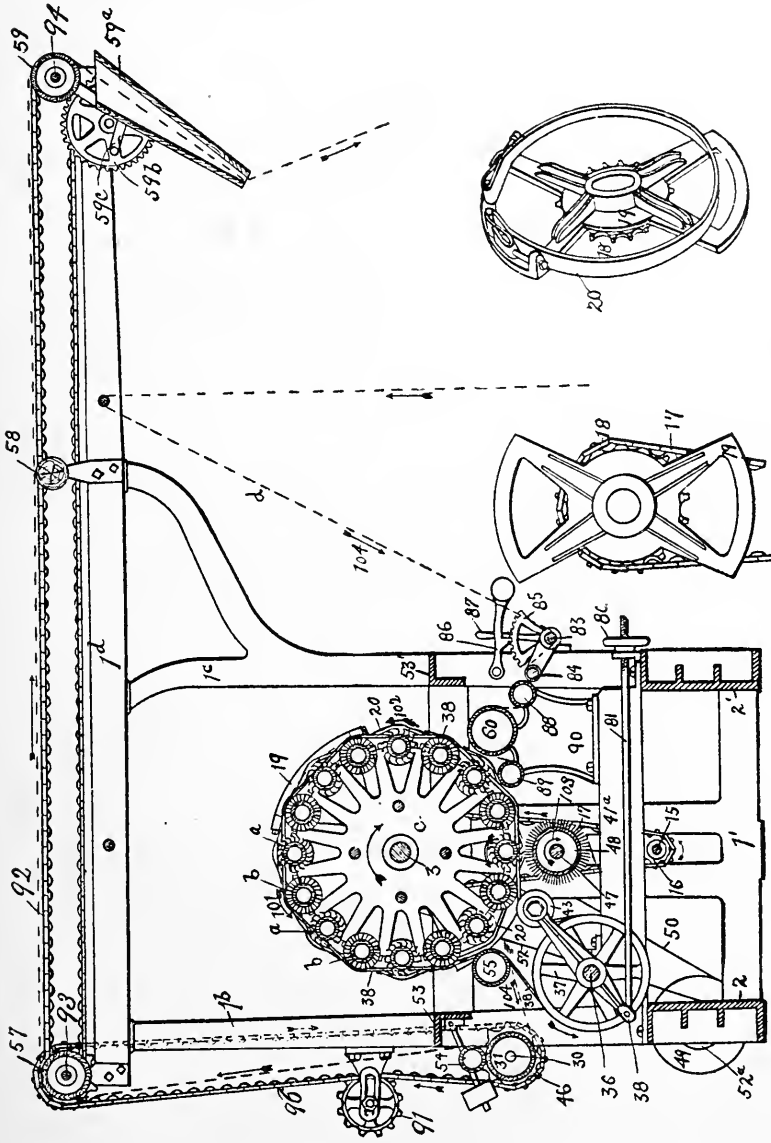


Fig. 33. Showing End View of David Gessner Napper.

upward and over the driven feed roll 57, over the idler 58 (overhead of the operator) and driven feed roll 59, whence it is delivered

through the folder 59^{c} behind the operator. The chain 96 is held taut by the idler 91 and drives the shaft 93, to which the feed roll 57 is fixed. Thence the driving power is transmitted through chain 92 to shaft 94, on which feed-roll 59 is fixed. Thence the driving power is applied to vibrating the folder 59^{a} through the wheel 59^{b} and connecting-rod 59^{c}.

The cloth enters the machine under the bar 83 and over the adjustable tension-bar 84, the adjustment of which is controlled by segment 85, catch 86, and hand lever 87, at the end of the bar 83. Thence it proceeds under idler 88, over the tension roll 60, under and around idler 89, directly in front of the napping cylinder. The idlers 88, 89, and the tension-roll 60 are mounted in brackets 90, which are fastened to brackets 41 and 41^{a}, extending across between the girders 2 and 2′.

The directions of movement of the drum-cylinder of each series of napping-rolls, and of the cloth, are respectively indicated by the arrows 100, 101, 102, and 104. The direction in which the brush 48 moves is indicated by the arrow 103.

The result is a nap much shorter, thicker, more evenly distributed, and more like a felt or "fleece" than the nap raised on a regular napper, the fabric handling much thicker and fuller even after washing or use and much less liable to become matted into bunches by rubbing or washing.

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are examples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for Civil Service Examinations. In some cases numerical answers are given as a further aid in this work.

REVIEW QUESTIONS

ON THE SUBJECT OF

KNITTING.

PART I.

---

1. How is the guage determined?

2. What style of outside circles do you consider most advantageous, and why?

3. How is a fleeced lined fabric made?

4. Explain the function of the clearing bur.

5. Where would you begin to set a feed?

6. How would you prevent the needles loading up?

7. What are the three things to be considered in preparing to make Single Plush?

8. What ought to be first done when a Winder runs hard?

9. What is the method of determining the weight of the yarn?

10. Having less than 50 yards of woolen yarn how would you find the size or run? What is the run and cut of 12 inches of woolen yarn which weighs $1\frac{1}{4}$ grains?

11. Why is the Winder a necessary machine in a Knitting Mill?

12. What are the principal differences in Spring Needle Machines?

13. Describe the function of the take-up.

14. How many burs in a plain feed are located inside the fabric on the needles, and what are they?

15. What objects are to be considered in determining the proper speed to run the cylinder?

16. What three objects ought a Knitter to keep in mind?

REVIEW QUESTIONS

ON THE SUBJECT OF

KNITTING.

PART II.

---

1. What effect does tucking the stitch have on the fabric?
2. Describe a 6 and 2 rib.
3. How is the tuck stitch made in automatic machines?
4. Describe what you consider the best method to even the stitch.
5. How does the royal rib or tuck stitch differ from plain rib knitting?
6. State the essential difference between a Plain and an Automatic Machine.
7. What is the pattern chain used for?
8. How are ribbed goods distinguished from flat goods?
9. What are the important members of a rib knitting machine?
10. If you desired to slacken the fabric, how would you proceed?
11. What extra work is done by the needle when tucking?
12. What is the take-up and what are its functions?
13. What is the advantage of the sectional cam ring?
14. Mention two conditions that will cause dropped stitches.
15. Describe the action of the hole and bunch detector.
16. How would you set a yarn guide or carrier?
17. How much space is it good practice to leave ordinarily between the needle cylinder and needle dial plate?
18. How would you proceed in replacing a press-off?
19. What are the advantages of the new method of measuring knitting machines?
20. Give a short description of how you would proceed to start up a machine that had been stopped for some time.

REVIEW QUESTIONS

ON THE SUBJECT OF

KNITTING.

PART III.

---

1. What is the difference between a Stationary Needle Cylinder Machine and a Revolving Needle Cylinder Machine?

2. What is the characteristic difference between the Leighton Machine and those common to the rib knitting type?

3. Describe the formation of the stitch on the Lamb Machine

4. How do common locks differ from cardigan locks?

5. How would you set a yarn guide on a Stafford & Holt Machine?

6. Give a short description of starting up a Scott & Williams Stationary Cylinder Machine.

7. What would you do in case the work persisted in rising up on the needle in a Lamb Machine?

8. How does knitting the royal rib or tuck stitch differ from knitting the plain rib?

9. How is the stitch adjusted on the Lamb Machine?

10. Describe the usual way of testing the amount of yarn the feeds are drawing and explain how they are adjusted.

11. How would you make a separating course on a Leighton Machine? What is it for?

12. How is a needle removed from the Lamb Machine?

13. Name some of the conditions which affect the speed at which a machine may be run.

14. Describe the action of shogging the stitch on the Leighton Machine.

15. What is the characteristic feature of the Lamb Machine?

16. Describe the functions of the latch openers.

REVIEW QUESTIONS

ON THE SUBJECT OF

KNITTING.

PART IV.

---

1. How is the fashioning or shaping to the leg done on a circular latch needle knitter?

2. How is the fashioning or leg shaping done on a flat rotary frame?

3. How would you change the size of stockings?

4. Describe the difference in the character of fabric made by tight and loose by knitting.

5. Why is it necessary to have different numbers of slots in needle cylinders?

6. What function do the sinkers perform?

7. What are the primary elements of the circular knitting machine?

8. How many movements are necessary to the needle cylinder in knitting a stocking?

9. Wherein is the two-and-one method of making heel and toe superior to the one-and-one method in circular machine knitting?

10. Describe the operation of the lifting pickers in the Acme machine.

11. In what respect does the circular ribbing machine differ from the circular stocking machine?

12. What is a slack course?

13. What is a welt?

14. How is a welt made?

15. Which fabric is the more elastic, that knit on the circular latch needle frame or that of the straight rotary spring needle frame?

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